GREATER RED LODGE PROJECT

Fire and Fuels Report

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INTRODUCTION

The Greater Red Lodge Project (GRLA) proposes approximately 1000-2000 acres of silvicultural treatments depending on action alternative. This analysis considers the affected environment and environmental consequences to fire and fuels**.** This analysis considers the effect of No Action (Alternative 1), the Proposed Action (Alternative 2), and two additional action alternatives (Alternatives 3 and 4). Proposed treatment includes commercial tractor logging (a mix of thinning and clearcuts), post and pole/teepee pole harvest, noncommercial hand and mechanical fuels treatment, pile burning, and/or broadcast burning.

A fire regime is defined as the nature of fire on the landscape over time. Fire regimes are further described by characteristics such as how often a landscape may burn, the common size of fires, and the severity of how fires typically burn (Agee 1993, Brown 2000). In wilderness and roadless areas of the Greater Red Lodge Project area, stand-replacing fire is natural and will continue to be the dominant disturbance agent in the larger landscape. However, within a buffer area of the wildland urban interface, the need exists to lower potential fire intensity through management intervention.

Significant road systems are lacking throughout much of the GRLA area. Due to the steep, inaccessible nature of much of the terrain and the lack of natural fuel breaks across the Beartooth Face, the preferred fuels management strategy of treating broader landscapes is limited. Working within the constraints of fire regime type, accessibility, and continuous fuels, the alternative fuels management strategy of treating in strategic areas to create a fuels altered zone is the best option available to land managers (Stratton 2004). These treated areas do not guarantee to stop the spread of wildfires but improve managers' abilities to confine wildfires to National Forest System Lands (NFS lands).

All treatment proposed by the Greater Red Lodge Project occurs within the Wildland Urban Interface (WUI). If a wildfire were to occur under current vegetation conditions, torching or crown fire is predicted across 48 percent of the treatment units and flame lengths greater than 8 feet would occur across 66% of the treatment units. Under the proposed action, torching or crown fire is predicted across only 1 percent of the treatment units and flame lengths greater than 8 feet would occur across 10 percent of the treatment units. This transition in fire behavior directly relates to firefighters' capacity to conduct suppression operations in the WUI.

The need for action to reduce hazardous fuels includes the following objectives:

- Reduce high-intensity wildfire within the Wildland Urban Interface (WUI) as identified in the Carbon County Community Wildfire Fire Protection Plan.
- Provide for a safer environment for the public and firefighters should a wildfire occur within the proposed treatment areas.
- To provide wildfire managers more suppression options to confine future wildfires from spreading beyond NFS lands.

Issues Related to Fire and Fuels

During project development, internal and external discussions revealed a number of issues relating to fire and fuels. These issues, which helped frame this analysis, include the following:

- Consider the threat to private lands and infrastructure from large, landscape wildfires.
- A more aggressive treatment approach is needed in the Willow Creek area.
- Fire history of the GRLA project area does not support the need for treatment.
- The danger from lightening fire cannot be properly mitigated because the area most susceptible to wildfire is higher on the Beartooth Face and cannot be reached for treatment.
- Provide proof that indicates the fire cycle in the project area has been disturbed by human activities and vegetation is unnaturally dense.
- The proposed fuels treatment will not help reduce fire hazard.
- Wildfires due to climate conditions are hard to control no matter what preparations (treatment) are completed.
- Mountain pine beetle mortality does not increase risk of wildfire once the needles have fallen off.
- Provide support that thinning forests will reduce crown fire and fire spread.
- Provide support that diversity of age classes reduces the risk of wildfire.
- Protecting private property is dependent on construction materials used to build structures and fuels treatment immediately around homes.
- Current stand conditions do not favor crown fire initiation.
- Thinning can result in faster rates of fire spread compared to un-thinned stands. There is a need to justify the benefits of the proposed treatments because of this effect.
- Because firefighter safety is a concern, discuss how specific fire suppression tactics would be altered by the proposed treatments.
- Disclose the effect of the proposed treatments over time.
- Describe the need for fire in sagebrush communities.
- Concern exists regarding the possibility of prescribed fires escaping.
- Because fire plays an important role in increasing diversity within forest habitats and influencing the way disturbances move across the landscape, prescribed fire should be used to compliment forest thinning activities.

The above issues will be discussed in various sections of the Greater Red Lodge Project fire and fuels report as appropriate for continuity of reading. It is the aim of this report to address how the proposed treatments will affect common fire behavior metrics including fire type (surface fire, torching fire, or crown fire) and flame length. Analysis will be provided through an examination of scientific literature and case studies as well as general discussion.

ANALYSIS AREA

Spatial Bounds

The analysis area for the Greater Red Lodge Project is 36,430 acres, stretching from Red Lodge Creek to the West Fork of Rock Creek along the Beartooth Face. A cumulative project area was identified for analysis in the fire and fuels report that consisted of the Red Lodge Creek Project Area, the Willow Nichols project area, and approximately 3,250 acres of Montana DNRC land. The resulting fuels cumulative project area is approximately 22,150 acres in size. State land was included in the fuels cumulative project area because of the fire behavior effects the DNRC Palisades Timber Sale will have.

Since this timber sale is currently being harvested, any fire behavior analysis was conducted using predicted post-harvest effects.

Temporal Bounds

Existing conditions or pre-treatment fire behavior was produced using on-the-ground conditions current as of 2012. Post-treatment fire behavior was produced for the year 2022 to allow for enough time for all treatment activities to be implemented. Only the analysis of effects for regeneration and intermediate treatments were projected into the future, in this case for the year 2052. Please see the section of this report regarding the modeling capabilities of the Forest Vegetation Simulator-Fire and Fuels Extension (FVS-FFE) to understand the capabilities of this model to produce outputs in the future.

REGULATORY FRAMEWORK

Cohesive Strategy

As required under the Federal Land Assistance, Management, and Enhancement (FLAME) Act of 2009, the Secretaries of Interior and Agriculture are required to submit a report to Congress on their efforts in producing an integrated wildfire management strategy. The Wildland Fire Leadership Council guided the development of the National Cohesive Wildland Fire Management Strategy, known as the Cohesive Strategy (USDA/DOI 2011), that provides consistent interagency direction by focusing on the following key areas:

1. Restore and Maintain Landscapes—Landscapes across all jurisdictions are resilient to disturbances in accordance with management objectives.

2. Fire Adapted Communities—Human populations and infrastructure can withstand a wildfire without loss of life and property.

Relevant performance measure:

- Risk of wildfire impacts to communities is diminished.

3. Response to Fire—All jurisdictions participate in making and implementing safe, effective, efficient risk-based wildfire management decisions.

Relevant performance measure:

- Injuries and loss of life to the public and firefighters are diminished.

Due to fact that all GRLA proposed treatments are located in the Wildland Urban Interface (WUI) adjacent to the NFS lands boundary, key area 1 will not be accomplished through the implementation of one of the GRLA proposed action alternatives. Resiliency will be improved at the stand level but not across the GRLA landscape. However, both performance measures identified under key areas 2 and 3 will be accomplished if the GRLA hazardous fuels objectives are realized through implementation of an action alternative.

Guidance for Implementation of Federal Wildland Fire Management Policy (2009)

This guidance replaces the Interagency Strategy for the Implementation of Federal Wildfire Management Policy (June 20, 2003). It consolidates and clarifies changes that have occurred since the

2003 strategy document was issued and provides revised direction for consistent implementation of the Review and Update of the 1995 Federal Wildland Fire Management Policy (January 2001).

This guidance does not pertain specifically to the GRLA treatments because this document provides broad direction for fire management and does not provide project specific guidance, but is relevant in that one of the guiding principles states that fire management programs and their associated activities need to support land and resource management plans and their implementation. In short, this policy is telling local fire management programs (in this case hazardous fuels reduction) to follow our forest plans (the Custer Forest Land and Resources Management Plan 1986).

National Fire Plan

In response to the landmark 2000 fire season, the federal officials began a process outlining how the nation can better respond to wildfire risks and emergencies. The result was the National Fire Plan (National Fire Plan 2002). A key objective the National Fire Plan identified was a collaborative approach to reduce the risk of future wildfires through the treatment of hazardous fuels.

Custer Forest Plan

Applicable fuels and fire related goals, objectives, standards, and direction identified in the Custer National Forest Land and Resources Management Plan (USDA 1986) as it pertains to the Greater Red Lodge Project (GRLA) are described below. Management area standards were provided for management areas in which proposed treatment may occur.

Forest-Wide Goals (USDA 1986, p. 4):

- The goal of air resource management is to meet or exceed state air quality standards and ensure protection of air quality related values.

The GRLA project would meet this goal because all prescribed burning activities would continue to work within the scope of our open-source burning permit issued by the state and monitored by the Montana Idaho Airshed Group.

Forest-Wide Objectives (USDA 1986, p. 5):

- Air quality of the National Forest System Lands will be maintained at or above levels required by Federal and State laws, regulations, and standards. The Forest Service will work with state and other Federal agencies to assure these standards are met.

The GRLA project would meet this goal because all prescribed burning activities would continue to work within the scope of our open-source burning permit issued by the state and monitored by the Montana Idaho Airshed Group. On a daily basis, a request is submitted via the Montana Idaho Airshed Groups website www.smokemu.org and burns are either approved or not approved through this same website.

Forest-Wide Standards (USDA 1986, pp. 21-39)

- Cooperating with Montana, North Dakota, and South Dakota Air Quality Bureaus in the Prevention of Significant Deterioration program and State Implementation Plans will protect air quality.

Requirements of the PSD, SIP, and State of Montana, North Dakota, and South Dakota smoke management plans will be met whenever the FS has the authority to do what is requires. The Forest will cooperate with states, other agencies, and organizations in identifying, evaluating, proposing solutions, and monitoring air quality problems associated with activities permitted on National Forest and National Grassland (USDA 1986, p. 26).

- Fire Management
  b) Using Level II and Level III analyses as guides, the Forest will develop and implement a Fire Management Action Plan that meets resource objectives and the following:
    1) Fire detection and suppression strategies to respond to threats to life and property, public safety and resource values.
    3) Fires threatening private land, human life, property, or improvements will be controlled as soon as possible (USDA 1986, p.38).
- A combination of treatments will be used that will most efficiently meets the fuels management direction of each MA. The Forest will consider the use of prescribed fire, using both planned and unplanned ignition as a management tool. Unplanned ignitions may be used throughout the Forest to meet MA goals when proper fire prescriptions have been developed and approved by the Forest Supervisor. When prescribed fire-planned ignition is part of the treatment, it will be carried out at a time and within a prescription that will minimize impacts on air quality and soil damage, achieve the desired results, and conform to the Northern Region Fuel Management and Treatment Guidelines (USDA 1986, p. 39).

The implementation of the proposed action will enhance the fire management goal of developing suppression strategies that respond to and control fires that threaten life, property, or improvements as soon as possible. Additionally, the proposed action treatments were designed with the most cost efficient method being used unless other circumstances prevent the use of a more efficient method.

Management Area Standards

Management Area B:

- Wildfire Management
  The control objective is to hold 90 percent of fire starts to less than 50 acres (USDA 1986, p. 47).
- Prescribed Fire
  Planned ignitions may be used for range and wildlife enhancement, fuels and debris reduction. Unplanned ignitions will not be used as a management tool on the National Grasslands, but may be used on National Forest Districts to enhance range and wildlife values and to restore the natural fire frequency. Acceptance and use of unplanned ignitions will be with a plan approved by the Forest Supervisor. The fire management plan will address specific requirements of the site, weather, expected fire behavior, and fuel conditions necessary for declaring an unplanned ignition a prescribed fire (USDA 1986, p. 47).

Management Area D:

- Wildfire Management
  The control objective is to hold 90 percent of fire starts to less than 50 acres (USDA 1986, p. 56).
- Prescribed Fire
  Planned ignitions may be used for range improvement and wildlife habitat, timber stand maintenance, fuels reduction, sanitation, maintaining vegetation, and associated wildlife habitat dependent on periodic fire. Unplanned ignitions will not be used as a management tool on the

National Grasslands. Unplanned ignitions may be used as prescribed fire on National Forest Districts under an approved fire management plan (USDA 1986, p. 56).

Management Area G:

- Wildfire Management
  The control objective is to hold 90 percent of fire starts to less than 25 acres (USDA 1986, p. 65).
- Prescribed Fire
  Planned ignitions may be used for timber stand maintenance and thinning, slash disposal, natural fuel reduction, wildlife habitat maintenance and enhancement with an approved prescribed fire plan. Unplanned ignitions may be used as prescribed fire to meet management objectives under an approved fire management plan (USDA 1986, p. 65).

Management Area R

- Wildfire Management
  The control objective is to hold 90 percent of fire starts to less than 25 acres (USDA 1986, p. 92).
- Prescribed Fire
  Planned ignitions may be used for hazard reduction, debris and slash disposal and maintenance of diversity for watershed values. Unplanned ignitions may be used under an approved plan to perpetuate stand diversity for watershed values (USDA 1986, p. 92).

DATA SOURCES, METHODS, AND ASSUMPTIONS

This section will discuss the data sources, methodologies, and assumptions used to compile this report.

Fire Terminology

A glossary of fire and fuels terminology can be found in Appendix A.

Data Sources

Fuels Data

The fuels data set was compiled using a combination of common stand exams, field visits, LANDFIRE geospatial data, and the following:

- Eastside VMap data was used to classify six forested cover types and 1 to 4 canopy cover classes used to obtain stand data. Fourteen individual strata were identified to assess forested conditions across the GRLA landscape using Forest Service Region 1 common stand exam protocols.
- FSVeg is a database storage system used to store information about trees, surface cover, down woody material, and vegetative composition. It was used to store common stand exam information and used as input data for the Forest Vegetation Simulator-Fire and Fuels Extension (FVS-FFE) model.
- LANDFIRE geo-spatial data is the result of an interagency effort between several federal land management agencies, the US Geological Survey, and the Nature Conservancy to provide comprehensive, consistent, and scientifically credible data for natural resource planning. LANDFIRE geospatial data about geographic, vegetative, and fuels attributes were used as inputs for the FlamMap fire behavior model. Also, LANDFIRE data was used to summarize the fire regimes and

Fire Regime Condition Class (FRCC) for the project area in Tables 4 and 6. Additional information on LANDFIRE can be obtained at: www.landfire.gov.

Climatology & Fire Behavior Thresholds

Local weather information was obtained from two remote automated weather stations (RAWS) located near Red Lodge, MT and Fishtail, MT. This weather data was obtained from the FAMWEB Website under Fire and Weather Data for the Timbercrest and Fishtail RAWS stations for the time period from 2000 to 2012. The computer program FireFamily Plus Version 4.0 was used to analyze fire weather parameters associated with fire occurrence data in determining fire behavior thresholds. These thresholds were identified by looking at weather conditions when large fires have occurred on the Beartooth Ranger District from 2000 to 2012. After examining summarized data from both weather stations, it was determined by Beartooth fire managers that fuel moisture and relative humidity outputs from the Timber Crest RAWS and wind speeds from the Fishtail RAWS best represented fire weather conditions for the GRLA project area. FireFamily Plus 4.0 was used to analyze this information and produce the 97th percentile fire weather conditions.

Fire History

Information about the historic fire record of the GRLA fuels cumulative project area came from a variety of sources. These sources include the following: anecdotal information gained through conversations with various individuals, a 1904 USGS description of forest conditions for the area, historic photo interpretation, and from a fire history study conducted by Rocky Mountain Research Station Research Biologist Elaine Kennedy Sutherland (publications in development).

Recent fire history records from 1970 to 2013 were collected from the FAMWEB website under Fire and Weather Data. Custer National Forest small fire (point fire) and larger fire spatial data was utilized in ArcGIS 10.0 to create project fire history maps.

Methods

1. Fuel Treatment Principles and Considerations

Fuels, weather, and topography influence fire behavior. Fuels are the only factor that management can modify. Fuels are made up of the various components of vegetation, live or dead, that occur on a site. These components include litter and duff layers, dead-downed woody material, grasses and forbs, shrubs, regeneration, and timber. Various combinations of these components define the major fuels groups of grass, shrub, timber, and slash. The differences in fire behavior among these groups are related to the fuel load and its distribution among the particle size classes. Fuel load and depth are critical fuel properties for predicting whether a fire will ignite, its rate of spread, produced flame lengths, and its intensity.

Fuel treatments reduce the crown and surface fuels by thinning trees and burning, removing, or chipping fuel on the ground. Table 1 describes the effects of some fuel treatment principles.

Table 1: Fuel treatment principles, effects, and advantages (Agee and Skinner 2005).

Fuel Treatment Principles

Principle	Effect	Advantage
Reduce surface fuels	Reduces potential flame length	Improves control and reduces torching
Increase canopy base height	Requires longer flame lengths to initiate torching	Reduces torching
Decrease crown density	Makes tree-to-tree crown fire less likely	Reduces potential for crown fire
Retain larger trees	Less tree mortality for same fire intensity	Increases trees survival

Fuel component characteristics contribute to fire behavior properties. Fuel loading, size class distribution of the load, and its arrangement (compactness or bulk density) govern whether an ignition would result in sustaining fire. Horizontal continuity influences whether a fire would spread or not and how steady the rate of spread would be. The loading and vertical arrangements of fuels influence flame length and the possibility of a fire burning into tree canopies (collectively called the overstory). With the proper horizontal continuity of the overstory fire can burn from tree crown to tree crown, also known as a crown fire. Fuel moisture content has a substantial impact upon fire behavior affecting ignition, spread, and intensity.

Crown fuels are described by canopy bulk density (the foliage contained per unit crown volume), canopy base height (the average height from the ground to the lowest living foliage), and canopy fuel load (the volume of canopy fuel load) (Scott and Reinhardt 2001). Crown fuels are important for determining crown fire characteristics, such as whether a fire can transition from the ground to the tree crowns.

2. Standard Fire Behavior Fuel Models

Fire behavior fuel models are a tool to help fire managers realistically estimate fire behavior of existing ground fuels. Each fuel model is described by:

- The fuel load and the ratio of surface area to volume for each size class.
- The depth of the fuel bed involved in the fire front.
- Fuel moisture, including that at which the fire will not spread (called the moisture of extinction).

The criteria for choosing a fuel model include selecting the fuel stratum(s) best capable of supporting fire. The difference between fuel models is a factor of fuel loading and fuel distribution. Fuel models correlate burning conditions for the severe period of the fire season when wildland fires pose greater control problems and impacts on land resources (Scott and Burgan 2005).

Two sets of fuel models were used for characterizing fuel beds in the GRLA project area. Anderson's (1982) original 13 fuel models were used as fuel model input for the FVS-FFE fire behavior model. To best represent fuel conditions in proposed treatment units and for the fourteen common stand exam strata developed for the larger landscape, up to three of Anderson's 13 original fuels models were selected and weighted by percentage of each fuel model represented in a given area. Due to the limitations of FlamMap 5.0 and BehavePlus 5.0 being able to accept only a single fuel model for fire behavior modeling, Scott and Burgan's 40 fuel models (2005) were utilized for characterizing fuel conditions as inputs for these fire behavior models. A crosswalk was created to correlate weighted Anderson 13 fuel models to the Scott and Bergen 40 fuel models (see Appendix B). For clarity in this report, the Scott and Bergan 40 fuel models are displayed to communicate the fuel conditions for both the proposed treatment units and the fuels cumulative project area.

A combination of field visits and LANDFIRE geospatial fuels data were used to determine fuel model assignments. Photo series guides (Fischer 1981, 1981a) were used to assist in assigning fuel models during site visits. Photo series guides provide visual methods of quantifying fuels loads and provide guidance of how fuel loads translate to particular fire behavior fuel models (Fischer 1981). LANDFIRE fuels data was utilized as it was provided from the LANDFIRE project or to reflect post-treatment conditions. Also, for areas where fuels personnel knew there have been fuel modifications since the LANDFIRE data was last refreshed in 2010, assigned fuel models were updated to reflect current fuel conditions on the landscape. Examples of areas where there have been changes to the fuel models classified by LANDFIRE include blowdown patches due to a wind event in 2007 and the DNRC Palisades Timber Sale units currently being harvested.

3. Fire Behavior Modeling

Fire behavior modeling is performed to estimate a number of fire behavior characteristics. There are three main categories of inputs to fire behavior modeling:

- Fuels
- Weather
- Topography

A combination of techniques were used to model fire behavior in the proposed treatment units and the GRLA cumulative fuels project area. The primary technique used for fire behavior modeling was the Forest Vegetation Simulator-Fire and Fuels Extension (FVS-FFE). This model provides a distinct advantage because it utilizes inputs directly derived from stand exam sampling and is able to accurately model vegetation effects for the variety of GRLA proposed treatment prescriptions (Bush 2014). FVS-FFE was used for fire behavior outputs for all the forested areas of the proposed treatment units and also for all the stands that were inclusive of the 14 common stand exam strata in the cumulative fuels project area. Fire behavior for non-forested areas of the proposed treatment units was modeled using BehavePlus 5.0 with inputs derived from field visits. Finally, fire behavior for the cumulative fuels project area not included in the 14 common stand exam strata or the proposed treatment units was modeled using FlamMap 5.0 employing LANDFIRE geospatial data. Fire travel paths and fire minimum travel times for the cumulative fuels project area were also modeled utilizing FlamMap 5.0 with inputs derived from forest canopy outputs from FVS-FFE, field visits, and LANDFIRE geospatial data. For further discussion of the three fire behavior modeling systems, see below.

- **Forest Vegetation Simulator-Fire and Fuels Extension (FVS-FFE)** This model simulates fuel dynamics and potential fire behavior over time in the context of stand development and management (Rebain et al. 2012). Since FVS-FFE incorporates forest growth models, forest mortality models, and seedling recruitment models, it is capable of modeling effects into the future. With the exception the analysis of regeneration and intermediate treatments, outputs were only utilized for existing and immediate post-treatment conditions. Forest canopy metrics of canopy height, canopy base height, and canopy bulk density were derived from stand exam measurements and modeled prescription effects. Fuel models for existing conditions and immediate post-treatment conditions (inside the proposed treatment units) were assigned based on field visits.

- **FlamMap 5.0** FlamMap 5.0 is a two-dimensional, non-temporal fire behavior modeling system. It is a spatial fire behavior model that creates calculations (for an instant in time) for all points in an analysis area, using one set of wind and fuel moisture conditions (USGS 2008). LANDFIRE geospatial data inputs include: canopy base height, canopy bulk density, canopy cover, canopy height, fire behavior fuel model, aspect, slope, and elevation. Part of the modeling process utilizing FlamMap 5.0 included updating LANDFIRE data to reflect post-treatment conditions and fuel modifications to the landscape not fully captured in the 2010 data refresh. To accomplish this data update, the landscape editor tool of the spatial fire behavior modeling software FARSITE 4.1 was employed.

  FlamMap 5.0 was also used to produce two modeled fire spatial outputs in the GRLA cumulative fuels project area. Simulations of two 5 acre fires that had escaped initial attack suppression efforts were conducted, one in the Red Lodge Creek area and one in the West Fork of Rock Creek. The spatial outputs utilized for analysis included the major travel paths the fire would take and the arrival times of fires from their original locations to two identified areas of values-at-risk. Both simulations were the products of the Minimum Travel Time (MTT) tool in FlamMap. The MTT tool calculates fire growth by searching for the set of pathways with minimum spread times from an ignition source (USGS 2008). Analysis of these outputs is in the environmental consequences section of this report.

- **BehavePlus 5.0** BehavePlus is a fire behavior modeling system that incorporates several models that predict the following: surface fire spread and intensity, crown fire spread and intensity, safety zone size, size of point source fire, fire containment, spotting distance, crown scorch height, tree mortality, wind adjustment, and probability of ignition (Andrews et al. 2008). BehavePlus inputs included fuel models, weather and fuel moisture variables, and terrain slope. Predicted flame length was the only surface fire intensity output utilized for the non-forested areas of the proposed treatment units.

4. Percentile Fire Weather

Fire behavior predictions were modeled for fuel moisture and fire weather conditions that occur at the 97th percentile during past fire seasons based on the occurrence of large fires on the Beartooth Ranger District since 2000. 97th percentile conditions mean that fuel moisture and fire weather conditions only exceeded the used values 3 percent of the time for the analysis period. Ten large fires were used to determine this threshold and with the exception of one fire, all fires occurred at or below 97th percentile conditions (see Table 2).

Table 2: Large fires on the Beartooth Ranger District by Energy Release Component (ERC). 97th percentile ERC during this time period was 71.

Large Fires on the Beartooth Ranger District 2000-2013			
Start Date	**Fire Name**	**Acres**	**ERC**
08/27/00	Willie	1,503	70
07/14/02	Red Waffle	5,859	64
08/14/03	Cathedral Peak	1,973	63
08/15/03	Saderbalm	859	64
08/22/06	Derby	207,115	66
07/26/08	Cascade	10,173	54

08/01/08	Tumble Creek	619	68
08/21/11	Hole in the Wall	6,318	62
08/28/12	Rosebud	2,396	81
08/20/13	Rock Creek	950	57

All of the identified large fires produced intense fire behavior to some extent. Although a full spectrum of surface fuel loads were represented, enough canopy fuels were present and the right weather conditions existed to produce crown fire.

Based on the rationale of utilizing 97th percentile conditions, the following fuel moisture and fire weather conditions were identified by analyzing data from the FAMWEB website using FireFamily Plus 4.0 software (see Table 3).

Table 3: 97th percentile weather conditions used for FVS-FFE, FlamMap 5.0, and BehavePlus 5.0 fire behavior modeling.

Percentile Weather	
Fuel or Fire Weather Characteristic	**97th percentile value**
1 Hour Fuel Moisture (%)	4
10 Hour Fuel Moisture (%)	4
100 Fuel Moisture (%)	6
1000 Hour Fuel Moisture (%)	8
Herbaceous Fuel Moisture (%)	30
Woody Fuel Moisture (%)	70
Max Temperature (°F)	87
20 Foot Wind Speed (mph)	21

Fuel moisture is the amount of moisture in a piece of fuel relative to its oven-dried weight. Fuel moistures are displayed in six categories based on the type of fuel (live or dead) and its size class. The size classes for dead fuels are as follows:

- 1 hour fuels are 0 to ¼ inch in diameter
- 10 hour fuels are ¼ to 1 inch in diameter
- 100 hour fuels are 1-3 inches in diameter
- 1000 hour fuels are greater than 3 inches diameter

Dead fuels are classified in this manner because different sizes of fuels take different amounts of time to gain or lose moisture, thus the number of hours associated with each (Anderson 1982). Live fuels are classified as either herbaceous or woody, depending on the type of plant.

Twenty-foot wind speed is the speed of the wind measured 20 feet above the vegetation. It is important to note that 20 foot winds are often three times the strength of the wind we feel on the ground in a forested area. For example, in a moderately dense conifer stand it would take a 20 mph 20 foot wind to produce a 6 mph eye level wind (NWCG 2006). Eye-level winds are often referred to as mid-flame winds because these are the winds that most directly affect surface fires. Mid-flame wind speeds are calculated from 20-foot winds by using a wind adjustment factor (NWCG 2006).

5. Spatial Analysis

ArcMap 10.0 software was used extensively for processing spatial fire behavior outputs and for creating the variety of maps used in this report. Data from the Custer National Forest Geographical Information System (GIS) library was used as the basis for the analysis.

Assumptions

When completing an analysis of a dynamic environment, at this scale, some assumptions are necessary from an efficiency stand point. The following are some assumptions used in this analysis:

- Fuels data used in this analysis are assumed to represent current on-the-ground conditions. Efforts were made to ensure that this assumption is true including field verification, photo series interpretation, and incorporation of remote sensing technology. At the time this report is written, no large-scale or catastrophic events are known to have occurred since the data for this project was compiled.
- GIS data used in this analysis is assumed to be accurate to within acceptable standards. This includes ownership boundaries, stand delineations, and project boundaries.
- Modeling of fire behavior using the methods described above gives a reasonable estimate of how fire behavior would respond to fuels treatments. The output modeled fire behavior provides a means to compare the proposed treatment alternatives.
- Passive crown fire and torching refer to the same type of fire behavior. Both are defined as fire that burns into the canopy of a single tree or group of trees. Throughout this report torching is used to refer to this fire type.
- Four fire type outputs are produced by FVS-FFE including surface fire, torching (passive crown fire), conditional crown fire, and active crown fire. A conditional crown fire can burn as a crown fire in a stand if it enters as a crown fire from an adjacent stand. These stands often have suitable canopy bulk density to carry crown fire but the canopy base height is high enough that a surface fire cannot easily transition to a crown fire in that stand. This fire type is contrasted with active crown fire which is defined as a crown fire in which the entire fuel complex becomes involved but the crowning phase remains dependent on heat released from surface fuels for continued spread. Active crown fires require surface fuels that burn above a critical intensity and flame length, moderate to high canopy bulk density with continuous crown fuels, and average to below average foliar moisture (Van Wagner 1977). For the purpose of analysis and clear communication in this report both conditional crown fire and active crown fire outputs were combined and were collectively called crown fire.
- Fire type for non-forested areas of the proposed treatment units was considered surface fire and added into surface fire acre summaries unless it was broken out in particular tables and noted. Shrub dominated areas will experience high intensity fire that burns the crowns of these plants but this fire type was considered surface fire.
- Treatments in Douglas fir and ponderosa pine stands are considered together for their effect to fire behavior because literature has found there is little difference in fuel treatment effectiveness between these two stand types (Omi and Martinson 2010).
- For cumulative effects modeling using the Minimum Travel Time tool in FlamMap 5.0, treatment units that were prescribed partial stand treatments (patch cutting or group shelterwood), the following rules were applied:

1) If less than 50% of the existing stand was treated, fuel models and canopy metrics (canopy height, canopy base height, and canopy bulk density) were left at the existing condition values for the entire unit.
2) If equal to or more than 50% of the existing stand was treated, fuel models and canopy metrics (canopy height, canopy base height, and canopy bulk density) were set to post-treatment values for the entire unit.

Fire Spread Model Assumptions

The surface fire spread model developed by Rothermel (1972) uses fire behavior fuel models to compartmentalize the physical and chemical fuel inputs necessary for the model. These assumptions apply to BehavePlus, FlamMap, and the Forest Vegetation Simulator-Fire and Fuels Extension (FVS-FEE). Additional models have incorporated substantive changes including spotting from firebrands (Albini 1979), crown fire initiation (Van Wagner 1977), and crown fire spread (Rothermel 1991) that have been combined in some of the fire behavior systems. The assumptions underlying the surface fire spread model assume homogeneity in what is naturally a dynamic system. It is therefore crucial to combine model outputs with professional judgment to ensure the results are valid and believable (Williams and Rothermel 1992). All model outputs were validated by fire management personnel at the Beartooth Ranger District. The following assumptions are essential when applying the surface fire spread model (NWCG 1989).

1. The fire is free-burning. Hence, suppression actions are not accounted for and the ignition origin is not influencing the fire.

2. Fine fuels less than 1 inch in diameter are more important to the fire's spread than larger fuels.

3. Fire is predicted at the flaming front (direction of maximum spread). The surface area to volume ratio of the fuels determines the residence time of the flaming front.

4. Fuels are continuous and homogeneous.

5. The basic spread model is for a surface fire burning within surface fuels. Smoldering and long-range spotting are not considered as they are outside the scope of the surface fire spread model. The fire spread model can predict torching, crowning, or spotting if combined with other models.

6. Weather is uniform and consistent.

7. Topography is uniform.

8. The model has been designed for peak fire season. July, August, and September are the peak fire months for the Beartooth Ranger District as the majority of acres have burned in these months.

9. The fire perimeter is based on a smooth ellipse.

FlamMap Model Assumptions

Refer to Finney 2006 and McHugh 2012 for more information regarding the assumptions and uses of this model.

1. Fire behavior is independent of neighboring cells.
2. Travel time across a cell is not influenced by neighboring cells in the Minimum Travel Time model.
3. The effect spotting has on fire spread is included in the Minimum Travel Time model.
4. Wind speed, wind direction, and fuel moistures are constant for the simulation period.
5. Fire spread due to rolling debris or falling snags are not included.

Scientific Accuracy

Modeling has often been described as both an art and a science. While some level of error or uncertainty exists, models are often utilized for providing insight and understanding regarding complex and intricate phenomenon. It is difficult to predict fire behavior due to the interaction of numerous dynamic components, including weather (windspeed and direction, temperature, and relative humidity), fuel moisture, topography, and the size of the fire front moving through. The best available science has been incorporated where possible in addition to professional judgment where scientific information is lacking or not available.

The fire behavior fuel models have been classified using the best available data. Post-treatment fire behavior fuel model conditions have been predicted based on expected vegetative response and professional expertise. The fuels are not always continuous or homogeneous. Acres per fire behavior fuel model and fire behavior fuel model proportions are presented in this report and represent conditions within the project area as close as possible.

All tables presented in this report have acres and proportions rounded to the nearest whole number. In cases where rounding resulted in the outcome being slightly less or slightly more than the actual acreage total or percent total, rounded numbers were adjusted to resemble the true total by adding or taking away a unit (one acre or one percent) from the nearest rounded value. Also, for the cumulative project area, acreage totals vary up to one percent. This is due to rounding and limitations of working with pixelated spatial data. Raw data is available in the project file.

MEASUREMENT INDICATORS

To describe the existing condition and the environmental consequences of the different alternatives, the following measurement indicators have been used for fire and fuels analysis:

Fire Behavior Indicators

1. Fire Type

The type of fire is very important in estimating how successful suppression efforts will be. The measurement indicators used for the analysis of fire type include the following:

Surface Fire – a fire that burns close to the ground surface including dead branches, leaves, and low vegetation. Surface fire is often considered by firefighters to be a lower intensity fire type.

Generally, surface fire is easier for firefighters to control but depends on flame length and rate of spread.

Torching Fire – a fire that burns into the canopy of a single tree or group of trees. This fire type can be an isolated flare-up and not present significant control issues or it can be the beginning of a transition to erratic and problematic fire behavior. Aircraft are commonly employed to suppress torching. This fire type is sometimes associated with spotting or the beginning stage of crown fire.

Crown Fire – a fire that spreads in the canopy of trees more or less independent of surface fire. This fire type is unpredictable and extreme. Crown fire is commonly associated with spotting. Crown fire cannot be directly attacked by firefighters or equipment, leaving only indirect attack and aerial resources such as helicopters and airtankers. Indirect attack involves building fireline a fair distance away from the main fire front. This fireline is usually fired from to create a burned buffer between the fireline and approaching fire front. Overall, suppression options are limited with crown fire and the best fire managers can hope for is that fire weather conditions will change. Firefighter and public safety stands the greatest chance of being compromised with this fire type.

2. Flame Length (feet)

Flame length categories also correlate directly to resist to control. Flame lengths are important to fire managers for determining which fire suppression techniques are most effective. The different flame length categories are commonly referred to as the Hauling Chart in fire suppression. The measurement indicators used for the analysis of flame length include the following flame length categories:

0-4 feet Direct suppression with firefighters is generally effective.

4-8 feet Suppression of flame lengths over 4 feet is generally unsuccessful with hand crews. Mechanized equipment can still be used successfully for suppression in this flame length category.

8-11 feet Aircraft including helicopters and airtankers can still be somewhat effective with these flame lengths depending on the type of fuel burning. Ground based resources (firefighters and mechanized equipment) are no longer effective. Fire behavior is fairly intense and difficult to control.

>11 feet All suppression resources are generally ineffective. Flame lengths greater than 11 feet are often associated with high rates of spread and exhibit considerable resistance to control. Sustained fire behavior of this nature presents significant risks to firefighter and public safety.

3. Percent Increase in Time

Percent increase in travel time was used as a metric two compare the effects of two simulated wildfires in the fuels cumulative project area.

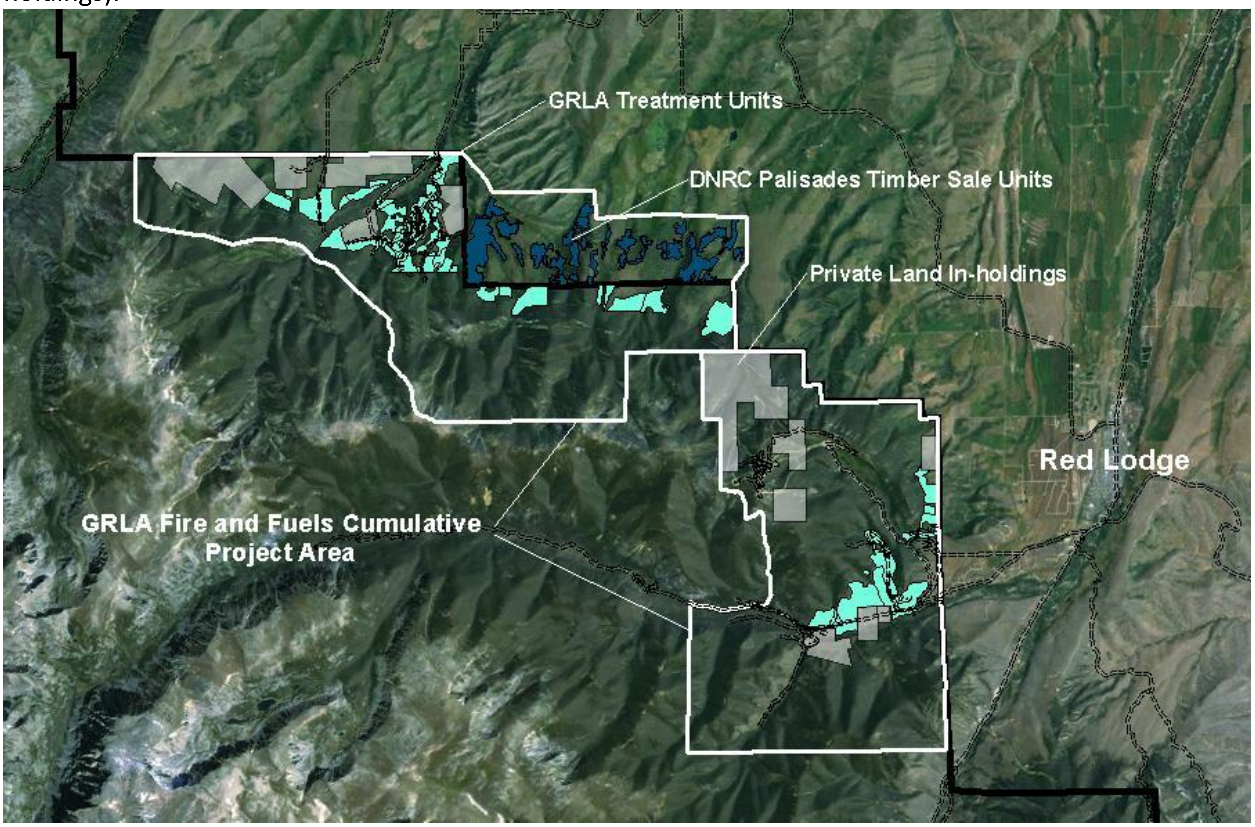
FIRE AND FUELS, AFFECTED ENVIRONMENT

Introduction

Analysis Area

The GRLA fire and fuels cumulative project area used for analysis (lands within the white boundary) include both the Red Lodge Creek and the Willow/Nichols project areas. In addition, the fuels cumulative project area includes 3,250 acres of Montana DNRC lands as a result of the current implementation of the DNRC Palisades Timber Sale (see Figure 1). Private land in-holdings were excluded from any analysis.

Figure 1: GRLA fuels cumulative project area (lands inside of the white boundary, excluding private in-holdings).



Historic Conditions

Published in 1904, John Leiberg, of the United State Geological Survey, provided a detailed account of forest conditions for the Absaroka Division of the Yellowstone Forest Reserve. This forest reserve of 1904 made up what presently are parts of the Custer Gallatin National Forest. By township, Leiberg described surveyed vegetation conditions and fire history of the period. Township descriptions are provided for the following townships inside the GRLA project area: Township 7 south, Range 18 east and Township 8 south, Range 19 east.

The Benbow-Little Rocky Fire History Analysis conducted by Sutherland (2014) was produced through tree ring fire scar sampling and tree age analysis. The study was conducted in the headwaters of Benbow and Little Rocky Fork creeks. These watersheds are located on the Beartooth Face approximately 20 miles to the northwest of the GRLA project. The Benbow-Little Rocky headwaters area shares many of the same attributes of aspect, elevation, slope, and forest types as the GRLA project area and was determined to be appropriate for fire history and fire regime analysis comparison. By sampling stand origination dates and fire scar evidence across multiple sites, both fire history and the fire regimes for an area can be described (Heinselman 1973, Arno and Sneck 1977, and McBride 1983).

Fire History

Leiberg (1904) described extensive burned over areas in both surveyed townships which would translate to areas of West Red Lodge Creek and the West Fork of Rock Creek. These burns were estimated to have occurred five to six years prior to when they were surveyed. This would date the fires to the late 1890's. Elsewhere in this official account of the newly declared forest reserves, Leiberg provides a general discussion of burns for the area. He estimated 70 percent of the forest reserve had been burned in the previous 120 years. He describes forests between 6,500 and 8,000 feet being dominated by lodgepole pine and estimated these forests burned periodically every 80 to 100 years.

In the Benbow-Little Rocky study area, tree ring fire scar analysis suggests a significant fire burned a large area of the Beartooth Face in 1886. Many stands of trees in the vicinity originated after this date implying a considerable area of this fire was stand-replacing. Other years that likely burned considerable acreages in the Benbow-Little Rocky area occur in the fire record up until the 1950's, particularly at lower elevations (Sutherland 2014). Anecdotal evidence and historic photo analysis also reveals much of the Beartooth Face experienced at least one stand-replacing event in the late 1800's. Pioneers from this time period described a fire that burned from the Boulder River watershed south of the Big Timber, Montana to the Red Lodge area. Historic photos of the West Fork Rock Creek from the 1910's reveal a near totally burned over landscape.

Sutherland's Benbow-Little Rocky fire history study also revealed many small, low intensity fires that did not kill the recording trees. Analysis of tree ages showed cohorts (groups of same-aged tree regeneration) developing throughout this period. This implies that there may have been locally severe fire behavior than opened the canopy and created growing space for tree regeneration, typical of a mixed-severity fire regime (Agee 1993). Fire scar and tree age data demonstrating the occurrence of this fire type are present throughout the fire history record for the study area (Sutherland 2014). Fire scarring ended in the low elevation ponderosa pine trees by 1915 but continued up to the present time in high elevations. The evident alteration since modern fire suppression (about 1950) is the cessation of new regeneration, which may indicate the effect modern fire suppression has had on fire spread and the homogenization of forest structure (Sutherland 2014).

Fire history pre-dating the landscape fires of the late 1800's can also be inferred from the Benbow-Little Rocky fire history study. In looking at stand origination before the late 1800's fires, Sutherland found great differences between the history of the Benbow and Little Rocky watersheds. The 1886 event in Benbow Creek was much more severe than the same fire in Little Rocky Creek; many more trees postdate that event. Evidence at Little Rocky shows trees originating around 1600, then the 1750's, and then the 1886 event. Although there is less certainty going this far back in the fire history record, stand initiation evidence would suggest a frequency of large, severe fires roughly every 120 years (Sutherland 2014).

Fire Regimes

A fire regime characterizes the how often a landscape burns, the commons sizes of fires that might occur, and the severity different fires may burn at. How often a landscape burns is generally referred to as fire frequency, or the recurrence of fire in a given area over time. Fire severity refers to the degree to which a site may be altered by a fire. Fire induced tree mortality is an example of severity. Areas of similar fire frequency, fire size, and fire severity are said to have a similar fire regime (Brown 2000).

Fire regimes for the fuels cumulative analysis area are displayed in Table 4. Both mixed severity and stand-replacement severity are well represented in the GRLA project area. The 80 to 99 year age class (age at diameter breast height) is the most represented age class across the proposed treatment units. An analysis of age class groups across the project area suggests that stand-replacing fire was common historically. For a more thorough analysis of existing age class groups, please see the silviculture report.

Table 4: Fire regime groups for the fuels cumulative project area.

Fire Regime	Acres within the Cumulative Project Area	Percent within the Cumulative Project Area
Fire Regime I, 0-35 yr. frequency, low to mixed severity	2	<1%
Fire Regime II, 0-35 yr. frequency, replacement severity	285	1%
Fire Regime III, 35-200 yr. frequency, low to mixed severity	10,469	48%
Fire Regime IV, 35-200 yr. frequency, replacement severity	7,963	36%
Fire Regime V, +200 yr. frequency, generally replacement severity	3,146	14%
Other*	5	<1%
Total	**21,869**	**100%**

*Other value consists of areas classified as barren ground, snow or ice, water, or non-classified.

Forest Conditions

Leiberg (1904) described forest conditions he believed resulted in large, intense fires of the time period. He identified these fires primarily occurring in the extensive lodgepole pine stands that existed. Large amounts of litter that had accumulated on a forest floor were identified as the primary factor in setting up stand-replacing fires. Leiberg cited two main sources of forest floor litter: 1) downfall from previous burns that occurred in an area and 2) downfall from trees that had died due to competition from high stocking rates.

Putting together the fire history for the Beartooth Face, the likely fire frequency in lodgepole pine stands for the area, and the fire regimes that exist across the GRLA project landscape; it is not unreasonable to believe that current conditions in the area are likely supportive of large, stand-replacing fire events. An examination of recent fire history provides insight to current trends across the Beartooth Face.

Existing Conditions

Current Condition Class Departures

Fire Regime Conditions Classes (FRCC) measures a landscape's degree of departure from historical conditions. An examination of FRCC for the Greater Red Lodge Project area can provide useful ecological context. Two main components are measured: 1) fire regime (fire frequency and severity) and 2) the associated vegetation. FRCC can be used to document possible changes to key ecosystem components. These ecosystem components include species composition, structural stage, stand age, canopy closure, and fuel loadings (Schmidt et al. 2002). One or more activities may have caused this departure including: fire exclusion, timber harvesting, livestock grazing, introduction and establishment of exotic plant species, insects and disease (introduced or native), or other past management activities (Laverty and Williams 2000).

The higher the condition class departure, the more the risk of losing key ecological components. Both fire regime and the associated vegetation are considered together to produce one overall condition class rating since the two components are dependent on each other. Fire regime condition classes are categorized by the National Fire Plan as follows (see Figure 5).

Table 5: Fire Regime Current Condition Class descriptions.

Fire Regime Condition Class		
Condition Class	**Attribute**	**Management Options**
1 Low Departure	• Fire regimes are within or near an historical range. • The risk of losing key ecosystem components is low. • Fire frequencies have departed from historical frequencies by no more than one return interval. • Vegetation attributes (species composition and structure) are intact and functioning within an historical range.	Where appropriate, these areas can be maintained within the historical fire regime by treatments such as fire use.
2 Moderate Departure	• Fire regimes have been moderately altered from their historical range. • The risk of losing key ecosystem components has increased to moderate. • Fire frequencies have departed (either increased or decreased) from historical frequencies by more than one return interval. This results in moderate changes to one or more of the following: fire size, frequency, intensity, severity or landscape patterns. • Vegetation attributes have been moderately altered from their historical range.	Where appropriate, these areas may need moderate levels of restoration treatments, such as fire use and hand or mechanical treatments, to be restored to the historical fire regime.
3 High Departure	• Fire regimes have been significantly altered from their historical range. • The risk of losing key ecosystem components is high. • Fire frequencies have departed from historical frequencies by multiple return intervals. This results in dramatic changes to one or more of the following: fire size, frequency, intensity, severity or landscape patterns. • Vegetation attributes have been significantly altered	Where appropriate, these areas may need high levels of conversion restoration treatments, such as hand or mechanical treatments. These treatments may be necessary before fire is used to restore the historical fire regime.

	from their historical range.	

Due to effective fire suppression for the last 50 years, the occurrence of low intensity wildfire has been reduced on the landscape. Fire return intervals have been affected for all forest types. Though mostly associated with a stand-replacing fire regime, low intensity fires were a part of the lodgepole pine historical fire regime. Also, a decrease of this type of fire has had effects to the mixed severity fire regime of Douglas fir and the common low severity fire regime of ponderosa pine. These fires created small scale diversity in several of the ecosystem components including: structural stage, stand age, canopy closure, and fuel loadings. The broader landscape should exhibit a greater distribution of disturbance patches created from fire which would have resulted in more heterogeneous stand conditions.

Most of the Greater Red Lodge project falls with Condition Class 2, showing a moderate degree of departure from reference conditions (see Table 6). The GRLA project does not propose to change the landscape condition class, but to use it as a useful context for understanding how current fire regimes and vegetation characteristics relate to historical conditions.

Table 6: Fire Regime Condition Class classifications for the cumulative project area.

Fire Regime Condition Class Group	Acres within the Cumulative Project Area	Percent within the Cumulative Project Area
Fire Regime Condition Class 1	4,221	19%
Fire Regime Condition Class 2	17,469	80%
Fire Regime Condition Class 3	117	1%
Other*	35	<1%
Total	**21,869**	**100%**

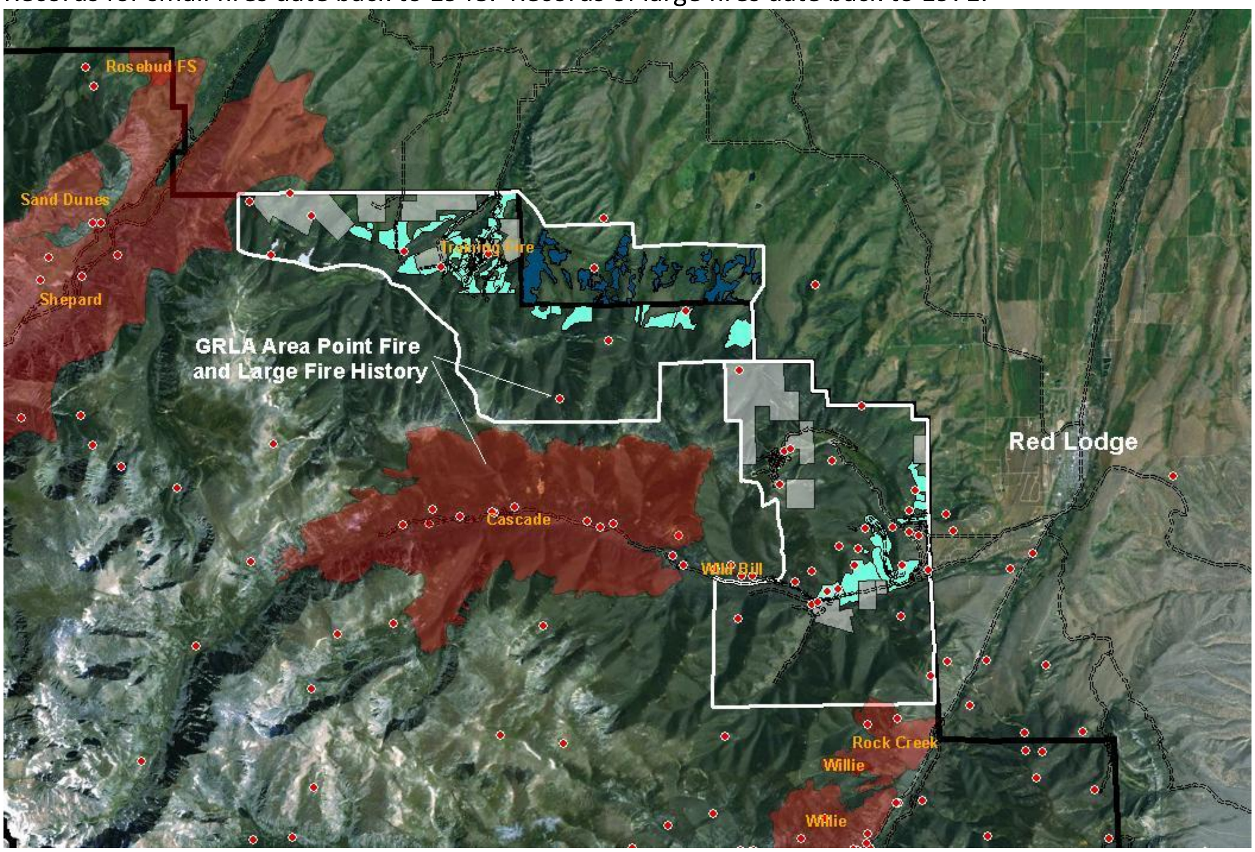
*Other value consists of areas classified as barren ground, snow or ice, water, or non-classified.

Recent Fire History and Suppression

Fire ignitions on the Beartooth Ranger District are caused equally by humans as well as lightening. Fire records from FAMWEB (Fire and Weather Data) website have captured 369 recorded fires dating back to 1970. Of these fires, 51% were human caused and 49% were the result of lightening. This is significant because it demonstrates an ignition can occur anywhere on NFS lands, from near the forest boundary to high up on the Beartooth Plateau in the Absaroka Beartooth Wilderness. Many human ignitions occur along roads, in dispersed campsites, or near established campgrounds. These fires are often close to the forest boundary in the Wildland Urban Interface (WUI). Lightning fires can occur randomly anywhere on the district. The significance is that large fires do not only occur high on the Beartooth Face due to lightning and then threaten to burn downslope, through the wildland urban interface, and onto private lands. Although this has happened, many fires also originate at low elevations and have the potential to increase in size and intensity in the WUI. The proposed treatments aim to reduce problematic fire behavior in either scenario.

Beartooth Ranger District fire records document that 40 wildfires have occurred inside the fire and fuels cumulative project area since 1949 (see Figure 2). Of these, the largest recorded fire was 38 acres in Red Lodge Creek. Immediately adjacent to the Greater Red Lodge Project, several large fires (Cascade, Shepard Mountain, and Rock Creek) have burned 26,014 acres and 36 structures in the last twenty years. These fires, although outside the GRLA project area, are relevant because the forest type and fire regime they burnt in were similar to what is inside the project area.

Figure 2: Small (point fires <10 acres in size) and large fire history of the Greater Red Lodge Project area. Records for small fires date back to 1948. Records of large fires date back to 1971.



Fire suppression on the Beartooth Ranger District has been very effective in catching most ignitions before significant acreage has been burned. Since 1970, 85% of the wildfires have been kept below 10 acres in size (FAMWEB). Of the remaining 54 fires in this same time period, multiple factors have contributed to the growth of these fires. Remoteness due to the extensive roadless and wilderness areas of the district have denied fire personnel quick access to many fires. Steep terrain and continuous fuels have also contributed to fire growth. Dramatic weather events including low relative humidity's, warm temperatures, and high speed, erratic winds have also contributed to several wildfires growing substantially in short periods of time. Both the Shepard Mountain (1996) and the Derby (2006) fires made dramatic runs is single burn periods. Fire management personnel strongly believe of many of our forested stands have reached mature or overmature stages of development and therefore have crossed a tipping point in which they are more capable of supporting large, high intensity fires (Stockwell and Brown 2014). These managers cite the number of increased large fires on the Beartooth District in the last two decades as proof that overall vegetation conditions on the landscape seem to have changed (see Table 7).

Table 7: Beartooth Ranger District large fire history since 1988 (fires greater than 500 acres in size).

Large Fires on the Beartooth Ranger District 1988-2013			
Start Date	**Fire Name**	**Acres**	**Structures Lost**
06/19/88	Storm Creek	97,858	-
08/12/90	Sand Dunes	910	-
04/05/91	Robertson Draw	3,300	-
09/07/96	Shepard Mountain	14,890	32
08/27/00	Willie	1,503	-
07/14/02	Red Waffle	5,859	-
08/14/03	Cathedral Peak	1,973	-
08/15/03	Saderbalm	859	-
08/22/06	Derby	207,115	20
07/26/08	Cascade	10,173	4
08/01/08	Tumble Creek	619	-
08/21/11	Hole in the Wall	6,318	-
08/28/12	Rosebud	2,396	-
08/20/13	Rock Creek	950	-

Hazardous fuels management has directly influenced suppression operations and fire behavior on the Beartooth District. Throughout the development of the GRLA project, references have been made to how fuels treatments in the Camp Senia Summer Home Area and Cascade Campground provided benefits during the Cascade Fire. Fuel reduction treatment cleaned up considerable ground fuels in these two areas caused during the winter 2007 blowdown event. This wind event effectively thinned or blew down patches of lodgepole stands in the area and left substantial slash loads on the ground. Fuels treatments cleaned up the blowdown prior to the Cascade Fire in 2008. This fuel treatment allowed firefighters to enter and re-enter the Camp Senia area to provide structure protection as the fire burned around the summer home tract. One primary structure was lost in the central summer home area that had received treatments. In areas adjacent to Cascade Campground, the wildfire burned into treated stands when no suppression personnel or equipment were present. Fire behavior subsided substantially and burned into treated areas as surface fire or failed to burn into some stands at all. Today, these areas are green "islands" surrounded by a landscape that mostly burned at stand-replacing intensity.

During the Rock Creek Fire in 2013, a rangeland conifer colonization treatment was tested. The fuels treatment had been conducted in 1999 and consisted of cutting colonizing Douglas fir and broadcast burning a traditional rangeland area. Broadcast burning had reduced slash generated during conifer cutting and reduced grass-shrub fuel loads. The day the Rock Creek fire started, it immediately threatened four primary residences located just down canyon from the fire. The fire burned slowly into the treated area and sometimes self-extinguished. Suppression resources utilized the treated area to cut fireline and burnout any remaining fuels to check down canyon fire growth. These quick actions secured the down canyon flank of the fire and greatly reduced fire movement towards the nearby threatened structures and the town of Red Lodge.

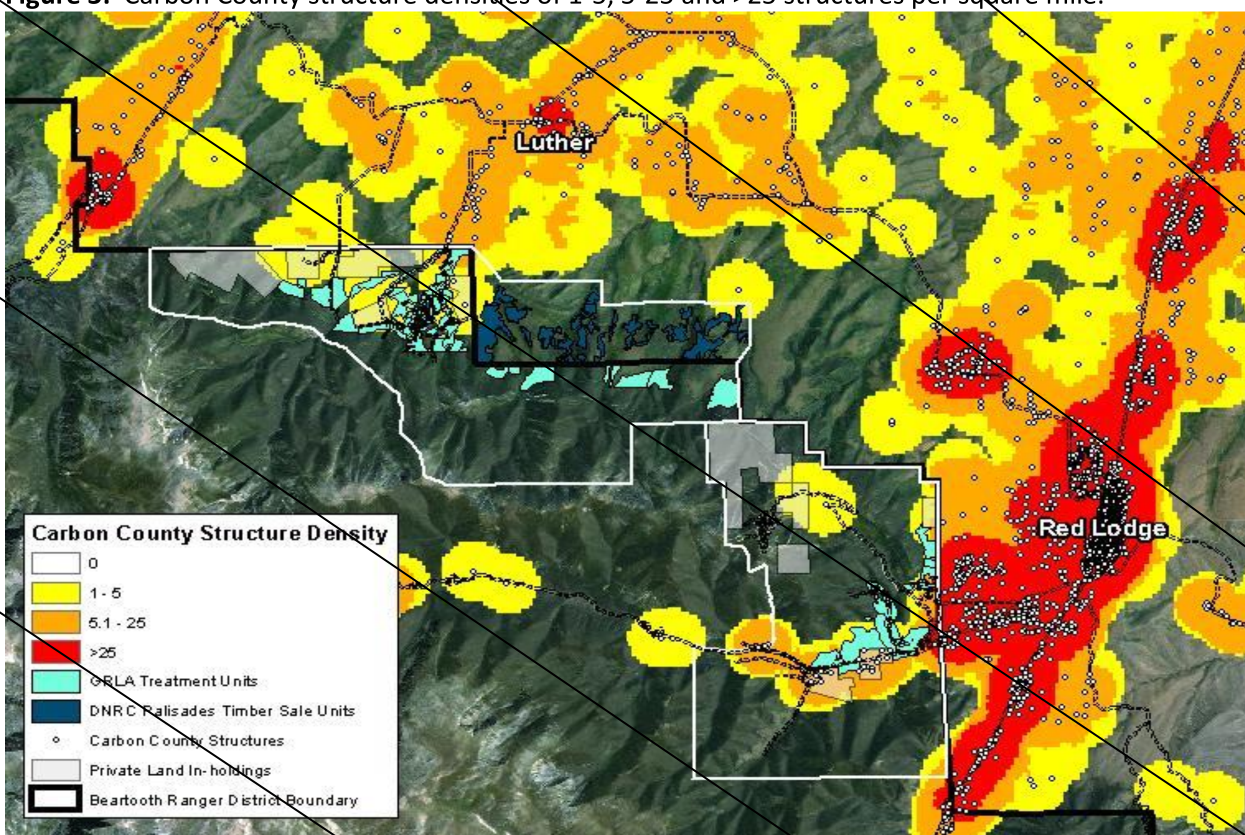
Wildland Urban Interface (WUI)

~~The Federal Register (Vol. 66, No. 3) defined the Wildland Urban Interface (WUI) as any place "where humans and their development meet or intermix with wildland fuel." Three categories of WUI were~~

~~identified, of which the most pertinent is *Category 2 -The Intermix Community*. This category was described as follows: the Intermix Community exists where structures are scattered throughout the wildland area (1 or more structures per 40 acres). There is no clear line of demarcation; wildland fuels are continuous outside of and within the developed area. The community of Red Lodge is included in the listing of communities within the vicinity of Federal lands that are at high risk from wildfire (Federal Register Vol. 66, No. 160).~~

~~The entire Greater Red Lodge Area project lies within Carbon County, Montana. In 2013, Carbon County officials revised their *Pre-Disaster Mitigation and Community Wildfire Protection Plan* (PDM/CWPP), (Carbon County 2013). This plan describes areas considered WUI in Carbon County. All areas proposed for treatment by the Greater Red Lodge Area project reside within designated wildland urban interface. The Carbon County PDM/CWPP identified the WUI situation in Carbon County to resemble *Category 2-Intermix Community*. Structure densities adjacent to the GRLA project treatment units vary from high to low (see Figure 3).~~

~~**Figure 3:** Carbon County structure densities of 1-5, 5-25 and >25 structures per square mile.~~



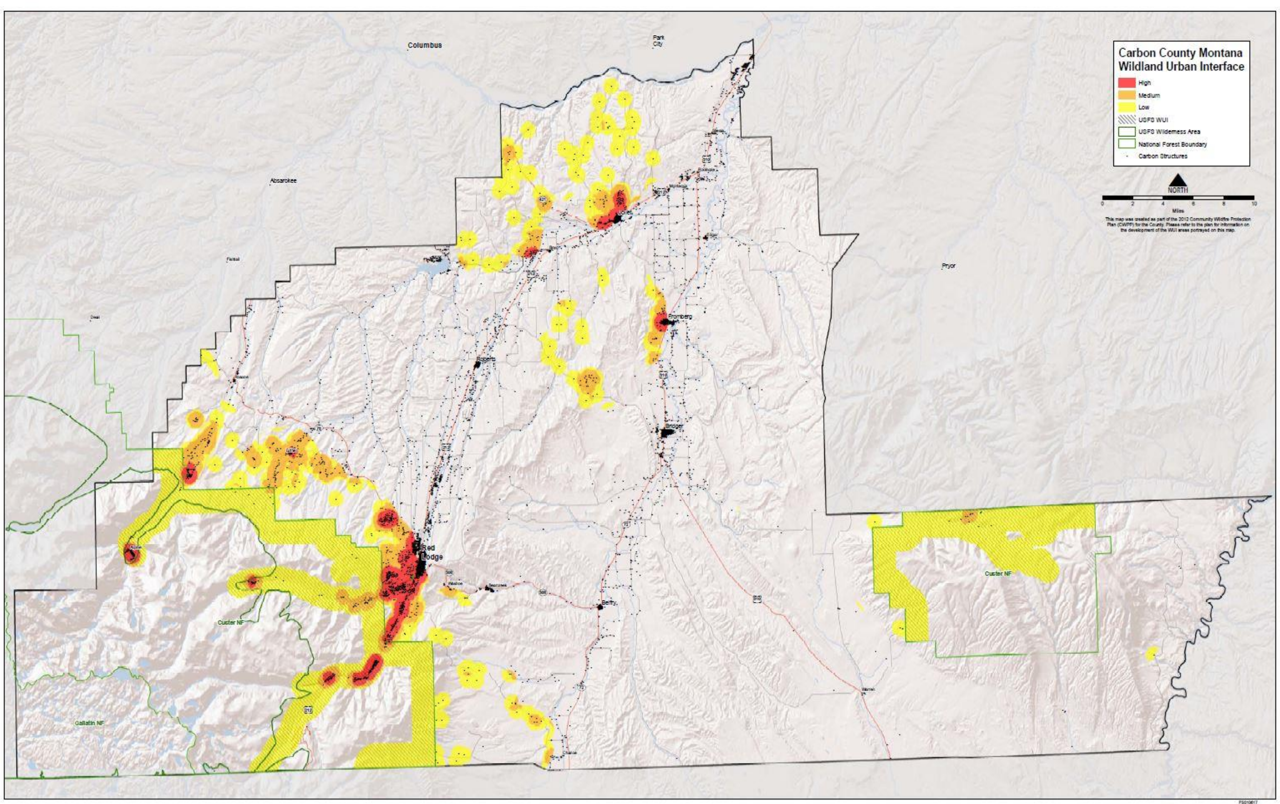
The Federal Register (Vol. 66, No. 3) defined a wildland urban interface community as "where humans and their development meet or intermix with wildland fuel." The community of Red Lodge is included in a national listing of wildland urban interface communities within the vicinity of Federal lands that are at high risk from wildfire.

The Healthy Forest Restoration Act of 2003 (HFRA) provides generic guidelines for determining WUI boundaries when a community wildfire protection plan is not in place. These generic guidelines recommend distances from a boundary of an at-risk community or an area adjacent to an evacuation route of an at-risk community to delineate WUI (16 USC 6511 (16)(B)). However, when a community wildfire protection plan is place HFRA specifies that the wildland urban interface for an at-risk community is what is identified in the community wildfire protection plan (16 USC 6511 (16)(A)).

The entire Greater Red Lodge Area project lies within Carbon County, Montana. In 2013, Carbon County officials revised their *Pre-Disaster Mitigation and Community Wildfire Protection Plan* (PDM/CWPP), (Carbon County 2013). This plan was developed through a collaborative approach involving Carbon County Commissioners, state and local governments, county fire chiefs, leaders from local health care providers, law enforcement officials, and managers from federal land management agencies. Public involvement was facilitated through a series of public meetings that presented the plan, answered questions, and encouraged public comment. The Carbon County PDM/CWPP meets all the requirements of the 2003 Healthy Forests Restoration Act for community wildfire protection plans (16 USC 6511(3)).

During the development of the PDM/CWPP, Carbon County officials evaluated whether the US Forest Service Region One HFRA WUI, 2004, was sufficient for adoption. The Forest Service identified this WUI spatial layer was created for use during broad and mid-levels of analysis and planning (USDA 2004). After Carbon County officials evaluated the Forest Service HFRA WUI, it was determined that a more detailed WUI map was needed for the Carbon County PDM/CWPP for local planning and project level use. CWPP developers adopted a four step methodology to define WUI within Carbon County and produce a final county-wide WUI map (Carbon County 2013). The result of this was titled "Carbon County Montana Wildland Urban Interface" and is depicted in Figure 3 below.

Figure 3: Carbon County Montana Wildland Urban Interface (Carbon County 2013, p. 5-30).

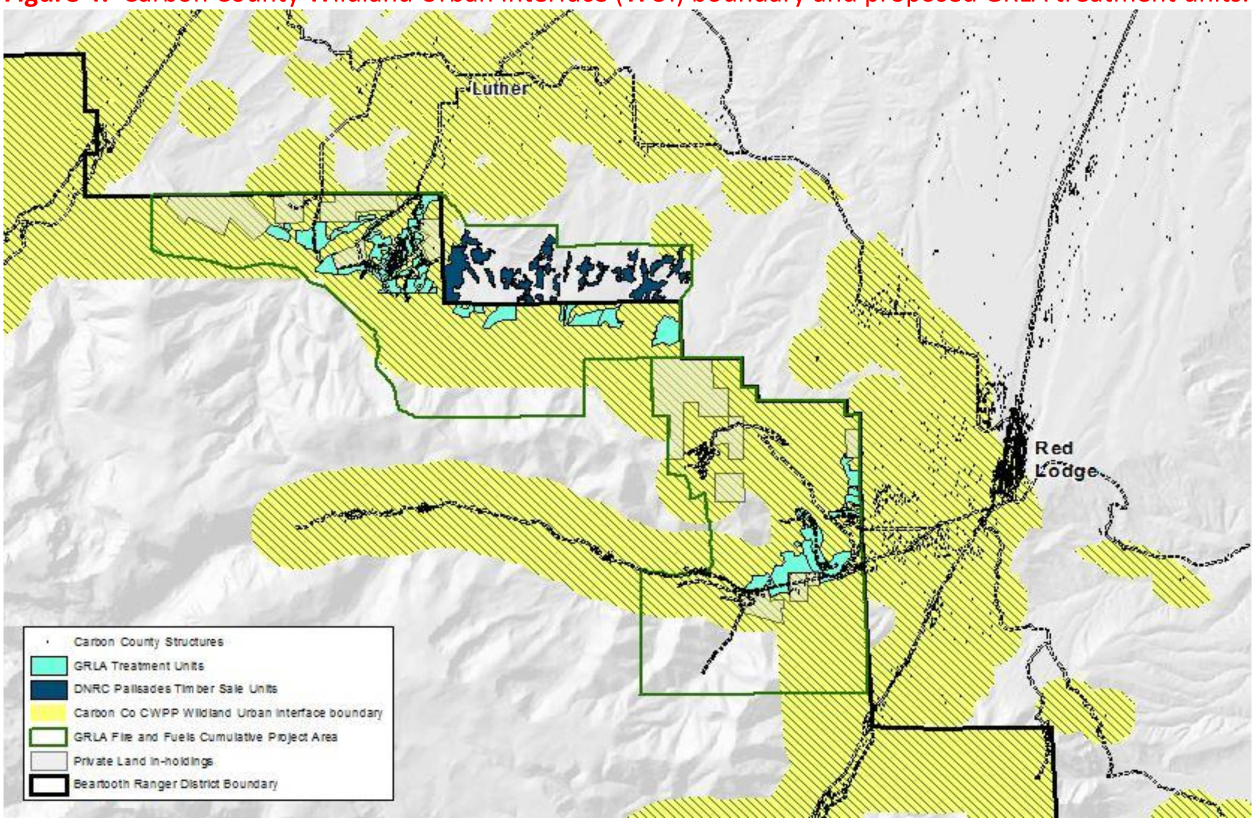


The Greater Red Lodge Area Project was given a ranking of high priority in the Carbon County PDM/CWPP listing of fire mitigation goals and objectives under *Goal 4 –Maximize protection of property from wildland fire in rural areas* (Carbon County 2013). Additionally this plan states:

> *Generally, the development of most concern in the county from the standpoint of fire protection is occurring south and west of Red Lodge along the wildland urban interface area against the boundary of the National Forest.*

All proposed treatment units of the Greater Red Lodge Area Project reside within the Carbon County PDM/CWPP designated wildland urban interface. Figure 4 depicts where these units (light green color) reside in regards to the WUI boundary. Units that are part of the DNRC Palisades Timber Sale (blue color) are also depicted on this map due to cumulative effects considerations but are not part of the Greater Red Lodge Area Project. Structures are also represented to give an approximate idea of structure density within and adjacent to the GRLA project.

Figure 4: Carbon County Wildland Urban Interface (WUI) boundary and proposed GRLA treatment units.



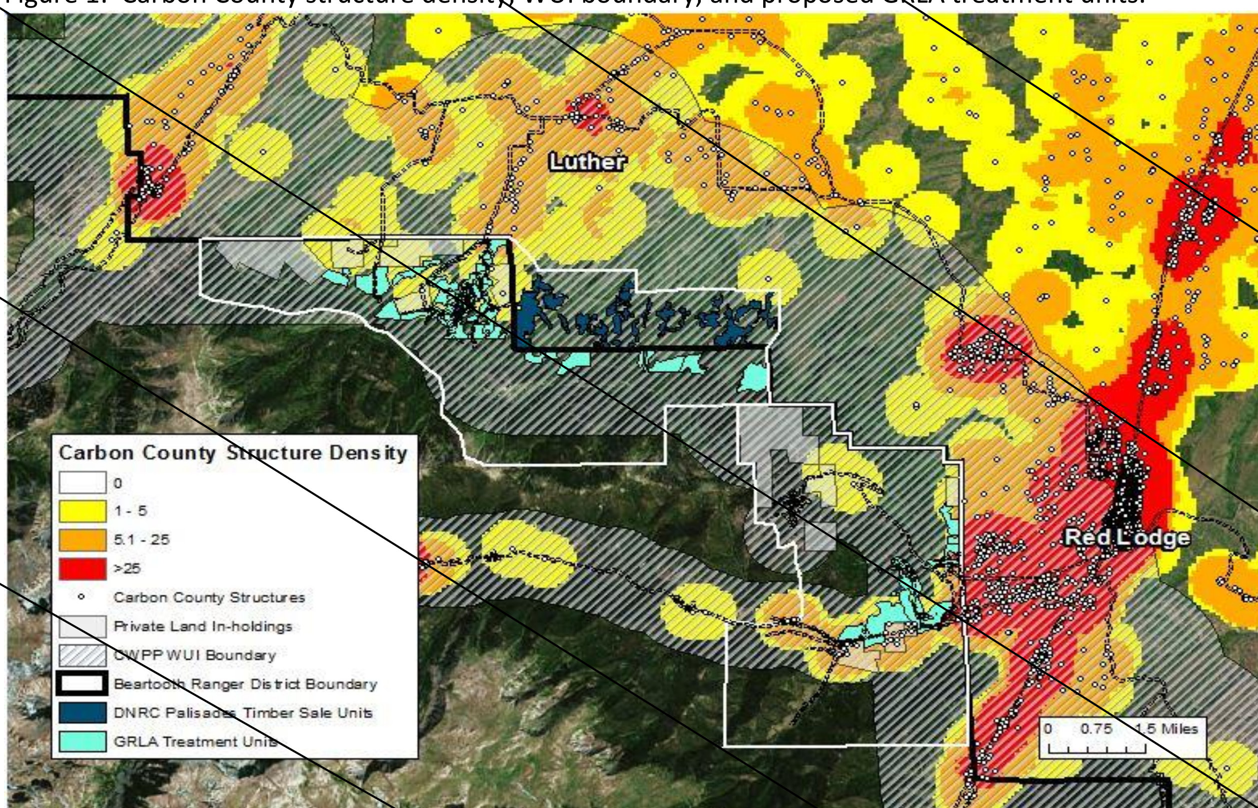
One of the objectives of reducing hazardous fuels is providing wildfire managers more suppression options to confine future wildfires from spreading beyond NFS lands. This objective needs to be considered in relation to the economic effects of wildfires in the wildland urban interface. Suppression expenditures typically increase as wildfire proximity to the WUI increases. In a case study analysis of ten large wildfires across the nation, Morton and others (2003) found the most costly economic impacts of wildfires result from damages to structures and private property. In a report of the efficacy of hazardous fuels treatments, the Northern Arizona Ecological Restoration Institute identified costs are multiplied when considering the damage caused by wildfires is often externalized beyond federal budgets across multiple levels of government and the private sector (Northern Arizona Ecological Restoration Institute 2013). These costs outside of direct suppression include private property losses, damage to utility infrastructure, fire evacuation costs, cleanup costs, lost tax revenues, property value losses, long-term rehabilitation costs including mitigating watershed damage and increases in invasive plant species, and even values placed on the loss of human life (Western Forestry Leadership Coalition 2009, Northern Arizona University Ecological Restoration Institute 2013). Many of these indirect costs can be related to the effect of fires burning into areas of human settlement in the WUI and the importance of increasing managers' options for keeping wildfires off lands owned by state and local governments or private individuals cannot be undervalued.

Greater Red Lodge Area Vegetation and Habitat Management Project, Final Environmental Impact Statement, Chapter 4

In the Greater Red Lodge Area Vegetation and Habitat Management Project, Final Environmental Impact Statement, Chapter 4, the following sentence and map are hereby removed from the response to Comment 83:

~~Incidentally, the Healthy Forest Restoration Act (HFRA) WUI boundary is provided in the PDM/CWPP and all of the vegetation treatments proposed by the Greater Red Lodge Area project fall inside the HFRA WUI boundary as well.~~

Figure 1: Carbon County structure density, WUI boundary, and proposed GRLA treatment units.



In place of the text removed from the response to Comment 83, the following text is added:

There is no need to identify that the project occurs within wildland urban interface as alternately defined by the Healthy Forest Restoration Act (within 1.5 miles of an "at-risk community" or an area adjacent to an evacuation route) when the Healthy Forest Restoration Act specifies that the WUI for an at-risk community is what is identified in the community wildfire protection plan (16 USC 6511 (16)(A)). The distance buffers or area adjacent to on evacuation route the Healthy Forest Restoration Act describes to designate WUI from an "at-risk community" only apply when a community wildfire protection plan is not in effect (16 USC 6511 (16)(B)). By recognizing only the Carbon County PDM/CWPP designated wildland urban interface, the Forest Service is following what the Healthy Forest Restoration Act directs federal agencies to do when a community wildfire protection plan is in effect.

Existing Forest and Fuel Conditions

Forested stands across the Greater Red Lodge Project area have had a variety of influences affect the current fuels condition across the landscape.

Over 70 percent of the forested stands are composed of lodgepole pine. Many of these stands are displaying signs of advanced maturity or overmaturity. Accumulating surface fuels are often a sign that lodgepole stands are becoming overmature (Brown 1975, Lotan et al. 1985). Surface fuel loads in these stands are building as a result of blowdown, endemic levels mountain pine beetle attack, dwarf mistletoe infection, western gall rust, and suppression mortality. Blowdown was often seen in association with western gall rust cankers developing in the main stems of trees during surveys of the proposed treatment units. This fungal infection manifests itself as a blister or dead area of a tree trunk. Cankers form weak areas in the tree stems and make them susceptible to wind snap. At other times, observed blowdown included the whole tree including root wad. Endemic levels of mountain pine beetle activity were witnessed repeatedly in lodgepole stands in the GRLA project area. Small pockets of several trees up to ½ acre mortality patches were observed. Beetle activity was witnessed to be on-going ranging from trees with green canopies but numerous beetle drill tubes, recently dead trees with red canopies, and older mortality that had shed their needles. Dwarf mistletoe brooms were witnessed in various lodgepole stands. These parasitic infections form clusters of thick branches that can serve as ladder fuels that transfer surface fire into tree canopies. Suppression mortality was pervasive throughout many lodgepole treatment units. This mortality results from competition for resources with other trees. Dead standing snags and different levels of lodgepole downfall has resulted from suppression mortality.

Several lodgepole stands have significant understories of shade-tolerant conifer species such as Douglas fir, Engelmann spruce, and subalpine fir. The fact that these are lodgepole stands but they have a shade-tolerant understory is also a sign that these stands are mature or overmature and probably approaching the end of their historical fire return interval (the time between two successive fires in a specified area). The development of this understory promotes conditions for a high intensity fire. Lotan et al. (1985) described how this is an advantage for a fire adapted seral species because a fire in an overmature stand will kill the shade-tolerant understory species and provide a seedbed for the regeneration again of lodgepole. For further information on sampled tree ages and stand dynamics of lodgepole, see the silviculture report.

Fuel conditions in the Douglas fir and ponderosa pine stands vary but also generally display the effects of a lack of recent fire. The number of trees per acre and a wide range of dominant, co-dominant, intermediate, and suppressed trees have created both significant canopy and ladder fuels. Understories of young, dense Douglas fir, ponderosa pine, and, in some cases, lodgepole pine exist. Also, buildups of timber litter and needle cast are significant in several stands. These effects would have commonly been mitigated by periodic low or moderate intensity wildfires. Presently however, these conditions have prepared these stands for uncharacteristic high intensity fire that would likely have higher severity effects than under historic conditions.

Many of the limber pine stands that were historically more savanna like in nature have been substantially colonized by Douglas fir. In some cases this colonization has advanced to the point that Douglas fir appears to be outcompeting limber pine for resources and many pine snags are present or remaining trees are of poor health. Dense, young Douglas fir colonization has also prepared these stands for high intensity wildfires that are likely going to have dramatic mortality effects for limber pine. Diseases such as blister rust and attacks from mountain pine beetle are causing significant mortality in some limber pine stands. Due to these forests often taking on the fire return interval of associated species (mountain grasslands, mountain big sagebrush, or Douglas fir) it is likely fires historically burned these landscapes at least once every hundred years (FEIS 2014). Missed fire return intervals appear to be moving succession along in these traditional rangeland settings to a predominance of Douglas fir with dire long-term effects for limber pine.

Another significant influence on fuels conditions in the Greater Red Lodge Project area is blowdown caused by significant wind events. As mentioned in the fire history section of this report, an anomalous wind event in November of 2007 caused 20,000 acres of blowndown on the Beartooth Face (Custer National Forest Fire Management Plan 2013). This event was responsible for significantly altering fuels profiles found on the forest and on some adjacent private lands. The most significant damage occurred on ridges or topographic features exposed to a southwest wind. Aerial mapping after the event captured areas where entire stands were laid down and also areas where the wind had a thinning effect of snapping off or blowing down weakened trees. Of the identified stands that were completely blowndown, only 77 acres of this effect was mapped inside the GRLA cumulative project area. However, storm damage that caused a thinning effect of weakened trees happened across upper elevations of the GRLA area as witnessed during field trips. This persistent lower level storm damage does exist, especially at elevations above the proposed treatment units and the effect is undoubtedly higher fire hazard conditions across this landscape.

Surface fuels are described with a fire behavior fuel model in order to classify fuels conditions for estimated potential fire behavior (Scott and Burgan 2005). Across the GRLA project area a variety of fuel conditions currently exist (see Table 8). Significant trends include both fuel models 184 and 183 that capture moderate loads of conifer litter including down logs caused by the mechanisms of blowdown, mountain pine beetle, and suppression mortality. Fuel models 165 and 161 identify both tall and short timber understories reflecting normal forest floor vegetation and the establishment of shade tolerant conifer species. Also notable is the Grass-Shrub fuel models 122 and 121 and Grass fuel models 102 and 101 that capture the existing fuel load (both moderate and low) of the non-forested areas of many of the rangeland conifer colonization treatment units.

Table 8: Fire behavior fuel model composition of the existing condition for the fuels cumulative project area.

Scott and Burgan 40 Fire Behavior Fuel Models		Cumulative Project Area	
		Acres	**%**
99	Bare Ground	202	1%

101	Grass (Sparse)	1,012	5%
102	Grass (Low Load)	683	3%
121	Grass-Shrub (Low Load)	258	1%
122	Grass-Shrub (Moderate)	747	3%
141	Shrub (Low Load)	12	<1%
142	Shrub (Moderate Load)	142	1%
161	Timber (Short Understory)	2,047	9%
165	Timber (Tall Understory)	7,488	34%
181	Conifer Litter (Low Load)	938	4%
183	Conifer Litter (Moderate Load)	2,587	12%
184	Conifer Litter (Small Downed Logs)	5,769	26%
185	Conifer Litter (High Load)	312	1%
188	Ponderosa Pine Litter	39	<1%
203	Blowdown (High Load)	43	<1%
	Total	**22,279**	**100%**

FIRE AND FUELS, ENVIRONMENTAL CONSEQUENCES

Effects Common to All Alternatives

Regardless of the chosen alternative, untreated areas will remain in the Greater Red Lodge Project areas. Wildland fire behavior in untreated areas depends on the fuels in addition to topography and weather. Some areas of critical habitat, such as areas identified as hiding cover or thermal cover for large game, can burn particularly well due to the contiguous crowns. During a wildfire in Oregon, all areas left untreated for wildlife habitat experienced crown fire, spotting, and group torching (Harbart et al. 2007). Given the current conditions within the project area, some untreated areas would be expected to suffer high intensity, stand-replacing fires due to current density, stand structure, and stand composition (Agee and Skinner 2005, Graham et al. 2004).

Over 70 percent of the combined Red Lodge Creek and Willow/Nichols project areas are dominated by lodgepole pine stands. Brown (1975) and Lotan et al. (1985) present the following lodgepole fire ecology. Historically, both low intensity and high intensity wildfires were common in lodgepole pine and a cycle of low intensity fires could set the stage for a large, stand-replacing event due to an accumulation of fire-killed downfall gradually building up fuel loads. Different maturity stages of lodgepole present different levels of fire hazard. Young stands can have a high fire hazard due to the low heights of tree crowns and high surface fuel loads as snags from previous fire events fall. Mid-maturity stands are characterized by moderate fire hazard due the openness of stands and the decomposition of surface fuels from previous disturbance events. Overmature stands gradually return to a state of high fire hazard as surface fuels build due to the effects of insect and disease mortality, competition mortality, duff build-up, blowdown, and shade tolerant species establishment creating dense understories. Variations in this described stand development pattern exist due to factors such as soil productivity, climate, habitat type, amount and severity of previous disturbance, and stand establishment success.

Lodgepole pine stands have probably become more homogeneous as a result of fire suppression. Effective fire suppression for at least 50 years has resulted in a reduction of acres burned by low intensity wildfires (Arno 1976). Maturity stage diversity created by low intensity, surface fires has been reduced and a predominance of overmature lodgepole stands have become common on the landscape.

Mechanisms of surface fuel buildup associated with overmature lodgepole set the stage for large, stand replacing wildfires (Lotan et al. 1985). The symptoms of overmature lodgepole stands are pervasive in the GRLA proposed treatment areas and were witnessed repeatedly during field visits.

Small patches of mountain pine beetle killed lodgepole pine are persistent throughout the proposed treatment units. These beetle killed pockets range in size from small groups of individual trees to patches up to ½ acre in size and multiple year mortality is common. The combined beetle hazard was modeled for Greater Red Lodge Project area utilizing stand inventory data stored in FSVeg and processed utilizing the Forest Vegetation Simulator (FVS). The combined beetle hazard considers mountain pine beetle (*Dendroctonus ponderosae*), pine engraver beetles (*Ips* species), and western pine beetles (*Dendroctonus brevicomis*). Forested areas rated high or moderate are more likely to experience significant mortality if insect populations are present and the weather is favorable (Randall et al. 2011). The existing condition combined beetle hazard for the GRLA project area is as follows: high (56%), moderate (41%), and low (3%). For a complete analysis of the project insect hazard, please see the silviculture report.

This combined beetle hazard rating for the project area has significant implications for the potential landscape fire behavior. In a review of 39 studies (peer reviewed journals and USFS General Technical Reports or Technical Notes), Hicke et al. (2012) examined the effect widespread conifer mortality would have as a result of a significant, landscape scale, bark beetle attack. Stand stages post-beetle attack (red phase 0-4 years post-attack, gray phase 5-10 years post-attack, and old phase >10years post-attack) were examined for the effect on fuels profiles and resulting fire behavior. Although disagreement existed between studies and further areas of analysis were identified, drops in foliar moisture, increasing surface fuel loads, and increasing intensity of different types of fire behavior (active crowning, torching, and surface fire) were trended across studies depending on the post-attack stage. Widespread mountain pine beetle mortality and the resulting changes in fuel profiles cause increased levels of both fire risk and fire hazard over time in a variety of pre-existing stand structures (Gray 2013).

Page et al. (2013) addressed recent science that fuels treatments were not warranted in mountain pine beetle (MPB) killed lodgepole pine stands. Through fire behavior simulations, Simard et al. (2011) modeled crown fire potential decreased in gray phase post-attack stands due to a decrease in canopy bulk density as dead needles were shed. Page et al. (2013) presented the following arguments regarding not only fire behavior, but also the ease of conducting effective suppression operations and firefighter safety. Combined, these criteria were used as a framework for evaluating the “resistance of control” fires in MPB affected stands pose (Page et al. 2013). MPB affected stands have more problematic fire behavior that is challenging to suppress and are more potentially dangerous to firefighters. Factors such as increased fireline intensity due to the sheer quantity of standing and down-dead fuels, increased spotting as a result of firebrands being transported by dead standing trees, and increased receptivity of dead, dry fuels for the development of spot fires ahead of established fire fronts all collectively lead to difficult fire behavior and fire suppression. Increased threat of snag strikes, increased escape times to safety zones due to heavy concentrations of downfall, and increased size of necessary safety zones due to overall increased fire intensity all compose potential threats to firefighters engaged in fire suppression operations in MPB killed lodgepole. By logically describing the overall increased resistance to control stands with significant mortality present, Page et al. (2013) recognize that people (firefighers and the public) are part of the wildland fire environment.

Effects Common to All Action Alternatives

Fuel treatments have been designed not to stop fire but to alter fire behavior in treated areas, thereby reducing the future effects of a potential wildfire (Omi and Martinson 2004; Reinhardt et al. 2008; Stratton 2004). Reducing fire growth in the heading direction (fire moving with wind and/or slope) offers the most substantial reductions to fire severity and fire size (Finney 2001). Finney's research shows fuel treatments with partial overlap serve to split a heading fire into numerous smaller fires (see Figure 4). As a wildfire is forced to flank treated areas rather than spread as a heading fire, fire progression is slowed and areas of severe fire effects are confined to smaller areas (Finney 2001).

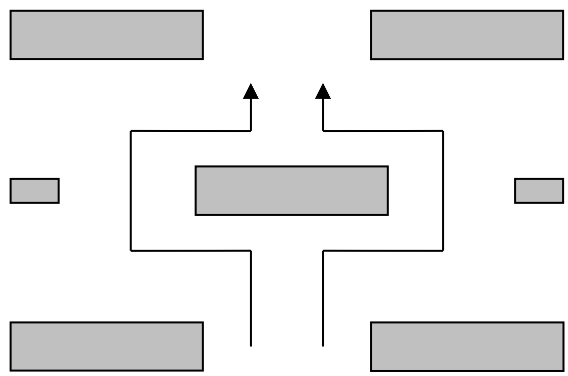


Figure 4: Depiction of fuel treatments (gray boxes) with partial overlap on the landscape that split heading fires (arrows) and force flanking between units (adapted from Finney 2001)

Expected changes to fire behavior can be achieved with both large and small units, although small units may not efficiently block fire movement through a large corridor (Finney et al. 2006a). To modify fire behavior, treatment units should overlap in the predicted direction of the heading fire. Due to predominant south, southwest, to westerly winds and alignment of the major drainages in the project area, proposed units should be aligned to overlap perpendicular to fires with a heading direction of north, northeast, or east as driven by down drainage winds or winds off of the Beartooth Face. As much as possible, proposed GRLA treatment units were identified to achieve this effect.

Where feasible due to road access and terrain steepness, areas identified for treatment were located to a sufficient distance or depth from the national forest boundary to help alleviate the development of new large fires due to spotting. Spotting distances up to three quarters of a mile are readily possible and can lead to the development of new large fires (Graham et al. 2004, Finney2001). With enough depth of treatment, large forested areas of receptive fuels have been broken up to prevent additional significant head fire runs in the fuels treatment zone.

Although, much of the GRLA project area proposed for treatment is lodgepole dominated and subject to stand-replacing fire, the concept of fire resiliency is applicable to the Douglas fir, ponderosa pine, and limber pine stands which compose approximately 20% of the proposed treatments. Four principles relating to fire resilient forests were contributed by Agee and Skinner (2005) including: (1) reduction of potential surface fire intensity, (2) reduction of potential torching by increasing height to live fuels, (3) reduction of canopy bulk density to decrease potential crown fire, and (4) retain large trees in the stand. Reducing canopy bulk density, surface fuels, and tree density while raising canopy base height are crucial criteria to consider when planning treatments to reduce fire intensity and the risk of crown fire (Graham et al. 1999; Peterson et al. 2003; Raymond and Peterson 2005). The proposed silviculture treatments in Douglas fir, ponderosa pine, and limber pine stands focus on thinning from below and slash fuels mitigation by broadcast burning (64%) and pile burning (36%). These treatments will effectively accomplish all four fire resiliency principles.

In the past years, research has been conducted in the western US on how fuels treatments affect wildfires that subsequently move through treated areas. The probability that a given acre is burned by a wildfire is low, and even lower when looking at the probability that a given treated acre be burned by a wildfire (Rhodes and Baker 2008). However, when looking at how wildfires burn through treated areas, treatments should be judged successful if desirable changes are made to fire behavior. Instead of focusing on the probability of a treated area experiencing a fire, the probability that a wildland fire is positively affected by a treated area should be judged more important (Finney 2008).

In general, vegetation treatments such as intermediate harvests decrease canopy bulk density, raise canopy base height, and increase average tree diameter (Omi et al. 2007). Canopy bulk density reductions are best achieved through reducing canopy fuels (removing trees) while increasing canopy base height is best achieved by reducing surface and ladder fuels (Omi et al. 2007). Thinning followed by prescribed fire seems to have the greatest reduction in fire severity and crown fire potential if a wildfire burns through a treated area (Omi and Martinson 2002; Omi et al. 2007; Prichard et al. 2010; Raymond and Peterson 2005; Skinner et al. 2005). Fire severity can be measured in terms of stand damage (crown scorch) and downward heat pulse (Omi et al. 2007). However, thinning alone can have no effect or even increase fire severity although the resulting stands favor surface fire over crown fire in the event of a wildfire (Omi et al. 2007; Prichard et al. 2010; Skinner et al. 2005). All thinning units that are not proposed for broadcast burning are required to meet slash residue guidelines (see post-treatment desired fuel loadings, Chapter 2) through whole tree yarding and hand or machine piling.

Prichard et al. (2010) explored post-wildfire effects in dry forest types and discovered a higher proportion of trees survived wildfire in units that had been thinned and prescribe burned (57 percent survived) than in units that had only been thinned without prescribed fire (19 percent survived) versus the control which had no treatments immediately prior to wildfire (14 percent survived). Bole char and crown scorch were substantially higher in thin and no-treatment control units as compared to those units that had been thinned and burned prior to wildfire (Prichard et al. 2010). Over 73 percent of large-diameter trees (greater than 8 inches DBH) survived following a wildfire in units that had been thinned and burned as compared to 36 percent survival in thinned units and 29 percent survival in no-treatment control units (Prichard et al. 2010).

In some stands that had been treated recently, wildland fires failed to spread into the thinned and burned areas (Finney et al. 2005; Raymond and Peterson 2005). Landsat 7 images taken during the Rodeo-Chediski Fire of 2002 in Arizona portray this wildfire burning in a chevron-shaped pattern on the lee side of treated areas and unburned inclusions (treated areas) within the fire perimeter (Finney et al. 2005). Thinning, pile burning, and underburning are effective methods for reducing crown fire hazard (Reinhardt et al. 2008; Scott and Reinhardt 2001). Regeneration treatments such as shelterwood have the ability to reduce ladder fuels and canopy bulk density as well as raise canopy base height depending on their application (Graham et al. 1999; Peterson et al. 2003).

Thinning from below by mechanical mastication has the same effect on forest structure as other forms of mechanical thinning (Harrod et al. 2009). Resulting surface fuel beds differ in that chipped fuels remain on site. Due to fuel bed compactness as a result of small slash particle size, surface flame lengths are low (2 feet or less), especially when masticated fuels are followed with prescribed burning(Harrod et al. 2009). Resulting forest structure and surface fuel profiles result in reduced crown fire hazard in treated stands (Hudak et al. 2011). Masticated fuels typically breakdown by five years post-treatment. Prescribed burning will be used in combination with mastication on 68% of proposed GRLA mastication treatment units.

These treatments serve to open stands and therefore increase midflame windspeed which can intensify surface fire, but the reduced crown fire potential and greater ease of control is often considered an acceptable tradeoff (Finney 2001; Scott and Reinhardt 2001). Given a 20-ft windspeed of 25 mph, thinning a fully sheltered stand (wind reduction factor of 0.2) to partially sheltered (wind reduction factor of 0.3) changes the midflame windspeed from 5 mph to 8 mph. This 3 mph increase is not likely to affect fire behavior substantially. A thinned stand can also enhance moisture loss in live and dead fuels due to increased insolation and wind (Pollet and Omi 2002; Reinhardt et al. 2008) as well as increasing fine fuel growth including grasses that increase a fire's rate of spread (Omi and Martinson 2004; Reinhardt et al. 2008). Elimination of ladder fuels and reduction of surface fuels should mitigate increased windspeed and drier fuel moisture by reducing the potential rate of spread and surface fuel loads (Peterson et al. 2005). Furthermore, application of prescribed fire in a thinned stand reduces surface fuels which can subsequently lower fire intensity (Graham et al. 1999).

While the effects of prescribed fire vary, numerous ecological effects must be considered. Fires create snags important for habitat and ecosystem diversity. In areas comprised mostly of fire-tolerant species such as ponderosa pine and Douglas-fir, fires consume duff and litter which inhibit grass and shrub growth. These conifers are insulated from fire due to the thick bark of mature trees, but can be killed if the cambium is subjected to sufficient heat exposure (Miller 2000). Often small fire-tolerant trees are killed and occasionally larger trees also die. Fires often kill conifer colonization in grasslands and shrublands and create habitat diversity in sagebrush by establishing a mosaic of age classes (Young 1983). For fire-intolerant species, fire often kills all the trees and sets these stands back to early seral condition. Many species have evolved with fire, such as lodgepole pine with serotinous cones (Miller 2000) and aspen clones that are stimulated following fire (Shepperd 2001). Fire can increase heterogeneity by creating habitat edges (Wrobleski and Kauffman 2003), consuming surface fuels, functioning as a part of the nutrient cycling process, and creating age class diversity. In designing Greater Red Lodge Project treatment prescriptions, efforts were made to capitalize on the benefits of prescribed fire. Pile burning was chosen over broadcast burning when on the ground specifics dictated broadcast burning implementation challenges existed or unit preparation expense could be excessive.

Prescribed burning often raises public concern over the potential for escape. All prescribed fire actions must be developed from resource and fire management objectives identified in the Custer National Forest Plan (USDA 1986) and the Custer National Forest Fire Management Plan (2013). A specific prescribed fire plan for each prescribed burn must be completed, reviewed, and approved before ignition can begin. This prescribed burn plan includes twenty three site specific elements that must be addressed prior to ignition to obtain desired resource management objectives on the ground. The Beartooth Ranger District is well aware of wind conditions and environmental constraints that face prescribed burning along the Beartooth Face and the burn plan will address proper conditions under which to implement the proposed prescribed burns.

In the Greater Red Lodge Project area, a portion of the mountain big sagebrush (*Artemisia tridentata subsp. Vaseyana*) in the West Fork of Rock Creek has been proposed for prescribed fire. Field observations noted a large proportion of this sagebrush as late seral and experiencing conifer colonization from Douglas fir. Prescribed fire would increase the early seral component and would be composed mostly of grasses and any islands of unburned sagebrush. Conifer colonization would also be reduced. Mountain big sagebrush would recolonize these burned sites over time as seeds are disseminated. Harniss and Murray (1973) report that mountain big sagebrush had higher yields (lb/ac) 30 years following prescribed fire than before burning and sagebrush may outcompete grasses due to the ability to grow deeper roots and make use of water unavailable to grasses. Prescribed fire has previously been used in mountain big sagebrush communities to restore composition and structure following examples of historic fire regimes and often results in a mosaic of burned and unburned areas (Wrobleski and Kauffman 2003).

The Greater Red Lodge Project purpose and need addresses the need to create vegetation conditions within proposed treatment units that are resilient to disturbances such as wildfires. Returning fire to the ecosystem as an important disturbance process has been cited as important step in restoring ecological resiliency (Wrobleski and Kauffman 2003). Fire additionally increases landscape heterogeneity, especially in areas that are suitable to grow trees in the absence of disturbance (Heyerdahl et al. 2006). Prescribed fire has been identified as a reliable method to kill conifer colonization and maintain productivity in mountain grasslands (Paysen et al. 2000). Based on research by Seefeldt et al. (2007) grass cover can recover by the second or third growing season following prescribed fire.

The proposed fuels treatments would create opportunities to utilize suppression tactics that are currently unavailable during periods of large fire growth under the existing fuels conditions. Under existing conditions, both torching and crowning fire behavior and flame lengths over 8 feet in height preclude direct attack by ground resources. Indirect tactics in which firefighters have to back off and utilize areas of light fuel loading, take advantage of natural fuel breaks, or simply allow enough time for suppression operations to be completed have to be utilized. This would mean backing off on to private lands, and many of the impacts described in the Wildland Urban Interface section of this document would become realized. It is the intention of the Greater Red Lodge Project to reduce impacts to private lands and development by altering the fuel profile and attempt to keep future suppression actions on National Forest System lands.

To different degrees, the proposed action alternatives would aid firefighters to engage in direct suppression operations due to predominance of surface fire and lower flame lengths. Thinned stands and reduced concentrations of brush and downed logs provide efficiencies in fireline construction. Also, due to lighter fuel loadings, indirect strategies such as the ability to conduct burnouts become available. Overall decreased fire behavior also allows the opportunity for firefighters to safely enter the treatment area to engage in structure protection.

Two case studies of the large wildfires that impacted central Idaho in 2007 are relevant to the suppression options that would become available as a result of the implementation of the Greater Red Lodge Project. These case studies are pertinent because they examined the effects landscape size wildfires had as they burned through a variety of implemented fuel treatments in a lodgepole pine, Douglas fir, and ponderosa pine mixed forest type. Hudak et al. (2011) pointed out that although there is a multitude of studies that examine the efficacy of fuel treatments in dry forest types, the fires in Idaho provided a substantial opportunity to examine the efficacy of fuel treatments in subalpine forests dominated by stand-replacing fire regimes. Energy Release Component (ERC) values were at or exceeded the 97^{th} percentile value and “red flag” fire weather conditions prevailed as both the Monument and North Fork fires (Cascade Complex) burned into wildland urban interface fuel treatments adjacent to the communities of Secesh Meadows and Warm Lake (Hudak et al. 2011). The fuel treatments allowed for areas to construct hand and machine fireline, conduct burnouts from, served as safety zones and areas to base structure protection from, and were used to develop the appropriate management response to wildfires (Graham et al. 2009, Hudak et al. 2011). Suppression crews could work from these areas and readily extinguish spot fires that occurred although high intensity, stand-replacing, wildfire occurred immediately adjacent to treatment areas (Graham et al. 2009). Bull et al. (2007) had the following to say about the how fuels treatments influenced decision making on the incident:

> *Not only did the presence of the fuel treatments directly impact the survivability of the many structures located within the basin, but they also influenced fire suppression strategies and the location of the Incident Command Post.*

Hudak et al. (2011) argued in their case study that fuel treatments on National Forest System lands and Firewise fuels treatments by private land owners complimented each other by giving firefighters the ability to safely move around in populated areas that were being defended while also reducing the direct likelihood that structures would burn. It is outside the scope of the Greater Red Lodge Project to conduct fuels treatments in the home ignition zone described by Cohen (2000) or to advise private property owners on what construction materials to use when building structures. However, one of the intents of the Greater Red Lodge Area Project is to provide fire managers the same improved suppression options that were realized by the treatments in Idaho. The Beartooth Ranger District will also continue to coordinate with and fully support the Beartooth Resource Conservation and Economic Development District's fuels reduction program which provides matching grants to private land owners to conduct fuels reduction on their properties.

Vegetation growth and succession are dynamic processes as can be reflected by changes in fire behavior fuel models over time. Both maintenance of treated units and treatment of new units are important to optimize treatment patterns over the landscape (Finney et al. 2005; Finney et al. 2006; Reinhardt et al. 2008; Omi and Martinson 2004). Treatments are effective for about ten years as related to potential fire behavior (Finney et al. 2006a; Omi et al. 2007).

Cumulative Effects

The cumulative effects analysis includes past, current, and reasonably foreseeable future activities as these activities influence fire and fuels. The fuels cumulative project area, an area approximately 22,150 acres in size, was utilized for this analysis. The effects of past activities dating to 1980 are addressed (this is as far back as accurate records for past activities exist). No effects of activities on private land in-holdings are reflected. The fire behavior unit of measure for consideration of all these activities is fire type. Effects are addressed in relation to how these activities influence surface fire, torching fire, or crown fire if they were to burn (see Tables 9, 10, and 11).

It is important to note that most of the effects of past and current activities on vegetation conditions or fuel loading were captured in the existing condition data set used for analysis. In this case the effects of these activities are reflected in the fire behavior outputs for the existing condition. Eastside Vmap data that was utilized for classifying the 14 individual common stand exam strata was current to 2005. All the stands in the cumulative fire behavior analysis that were inclusive of these strata reflect past activities up to 2005. LANDFIRE geospatial data used for the cumulative fire behavior analysis outside of the stands captured by the 14 strata was current to 2010. The effects of all past activities in the proposed treatment units are captured up to the current date through stand exams or field visits that occurred shortly before effects analysis of the GRLA project began. Additionally, LANDFIRE datasets were modified to capture the effects of the DNRC Palisades Timber Sale which is currently being harvested (i.e. an effect of a current activity). In short, there is only a brief time period for which past activities were not modeled for in the existing condition analysis.

Table 9: Effects of past activities to fire and fuels.

Activity Name	Decade or Year	Scope of Activity	Resource Effects
1980-1989			
Forest Service Regeneration Harvest - Commercial	1980 - 1989	Harvest: 35 ac	Treatment greatly reduced crown fire hazard by clear-cutting and removal of material. Surface fire intensity reduced through slash mitigation. Conifer re-establishment and increasing surface fuels contributing to higher fire behavior hazard. Small inclusions of crown fire, torching, and increased surface fire intensity expected within past treatment areas. Treatment effectiveness approximately 20 years.
Forest Service Intermediate Harvest - Commercial	1980 - 1989	Harvest: 11 ac	Treatment reduced crown fire, torching, and surface fire hazard by decreasing stand density and slash mitigation. Effects are diminishing over time due to canopy mortality from competition, blow-down and small pockets of endemic beetle kill. Inclusions of crown fire, torching, and increased surface fire intensity expected within past treatment areas. Treatment effectiveness approximately 10 years.
Forest Service Non Commercial Treatments	1980 - 1989	Treatment: 50 ac	Treatment consisted of conifer thinning primarily along corridors. Less canopy thinning occurred than Intermediate Harvest, therefore, crown fire hazard reduced, but to a lesser degree. Inclusions of crown fire, torching, and increased surface fire intensity expected within past treatment areas. Treatment effectiveness approximately 10 years.
1990-1999			
Forest Service Aspen Regen	1990 - 1999	Treatment: 151 ac	Fire and fuels hazard reduced by treatment shifting representative fuel model to a brush fuel model that typically experiences less active fire behavior. Surface fire hazard due to residual slash. Treatment longevity varies depending on conifer re-establishment.
Forest Service Aspen Enhancement	1990 - 1999	Treatment: 12 ac	Fire and fuels hazard reduced by conifer removal shifting the representative fuel model from a brush/timber understory to a brush fuel model that typically experiences less active fire behavior. Surface fire hazard due to residual slash. Treatment effectiveness approximately 15 years.
Forest Service Regeneration Harvest - Commercial	1990 - 1999	Harvest: 75 ac	Treatment greatly reduced crown fire hazard by clear-cutting and removal of material. Surface fire hazard reduced through slash mitigation. Effects diminish as conifers re-establish. Inclusions of torching and increased surface fire intensity expected within past treatments. Treatment effectiveness approximately 20 years.

Forest Service Intermediate Harvest - Commercial	1990 - 1999	Harvest: 2 ac	Treatment reduced crown fire, torching and surface hazard by decreasing stand density and slash mitigation. Effects are diminishing over time due to canopy mortality from competition, blow-down and small pockets of endemic beetle kill. Small inclusions of crown fire, torching and increased surface fire intensity expected within past treatment areas. Treatment effectiveness approximately 10 years.
Forest Service Non Commercial Treatments	1990 - 1999	Treatment: 44 ac	Treatments consisted of conifer thinning primarily along corridors. Less canopy thinning occurred than Intermediate Harvest, therefore, crown fire hazard reduced, but to a lesser degree. Inclusions of crown fire, torching and increased surface fire intensity expected within past treatment areas. Treatment effectiveness approximately 10 years.
Forest Service Prescribed Fire	1990 - 1999	Prescribed Fire: 383 ac	Treatment often removed conifer colonization and reduced fuel loadings in grass and shrub fuel models. Crown fire, torching and surface fire hazard reduced. Effects are diminishing over time as brush and conifers re-establish. Inclusions of torching fire behavior and increased surface fire intensity are expected within past treatment areas. Treatment effectiveness approximately 10 years.
2000-Present			
Forest Service Aspen Regen	2000 - Present	Treatment: 54 ac	Fire and fuels hazard greatly reduced due to treatment shifting activity area to a representative brush fuel model that typically experiences less active fire behavior. Surface fire expected within past treatments. Treatment longevity varies depending on conifer re-establishment.
Forest Service Aspen Enhancement	2000 - Present	Treatment: 90 ac	Fire and fuels hazard greatly reduced by conifer removal shifting the representative fuel model from a brush/timber understory to a brush fuel model that typically experiences less active fire behavior. Surface fire expected within past treatments. Treatment effectiveness approximately 15 years.
Forest Service Intermediate Harvest - Commercial	2000 - Present	Harvest: 59 ac	Treatment reduced crown fire, torching and surface fire hazard by decreasing stand density and slash mitigation. Effects diminish over time due to canopy mortality from competition, blow-down and small pockets of endemic beetle kill. Small inclusions of torching and increasing surface fire intensity expected within past treatments. Treatment effectiveness approximately 10 years.
Forest Service Non Commercial Treatments	2000 - Present	Treatment: 232 ac	Treatment consists of conifer thinning primarily along corridors. Less canopy thinning occurs than Intermediate Harvest; therefore, crown fire hazard is reduced, but to a lesser degree. Small inclusions of torching and increasing surface fire intensity expected within past treatments. Treatment effectiveness approximately 10 years.
Forest	2000 -	Prescribed Fire: 154 ac	Crown fire hazard and surface fire hazard reduced due to

Service Prescribed Fire	Present		the removal of conifer colonization and reduction in fuel loading in the grass and shrub fuel models. Effects diminish over time as brush and conifers re-establish. Surface fire expected within past treatments. Treatment effectiveness approximately 10 years.

Table 10: Effects of current activities to fire and fuels.

Activity Name	Implementation	Scope of Activity	Resource Effects
DNRC Palisades Timber Sale Regeneration Harvest - Commercial	2014	Harvest: 700 ac	Crown fire and torching will be eliminated by clear-cutting and removal of material. Slash mitigation will decrease surface fire hazard. Surface fire expected within treatment units. Treatment effectiveness approximately 20 years.
DNRC Palisades Timber Sale Intermediate Harvest - Commercial	2014	Harvest: 89 ac	Crown fire and torching hazard will almost be eliminated through canopy thinning decreasing canopy bulk density. Slash mitigation will decrease surface fire hazard. Surface fire expected within treatment units. Treatment effectiveness approximately 10 years.
Red Lodge Mountain Ski Area Vegetation Management Plan Non Commercial Treatment	2013 -2014	Treatment: 10 ac FS Land	Treatment consists of conifer thinning and slash mitigation. Less canopy thinning will occur than Intermediate Harvest, therefore, crown fire and torching will be greatly reduced. Surface fire expected within treatments units. Treatment effectiveness approximately 10 years.
Forest Service Non Commercial Treatments	2014	Treatment: 39 ac	Treatment thins conifer colonization in rangelands. Crown fire and torching hazard will be greatly reduced due to significantly reduced conifer stocking. Surface fuels will deteriorate resulting in a decrease in surface hazard. Surface fire expected within treatment units. Treatment effectiveness approximately 10 years.

Table 11: Effects of reasonably foreseeable activities to fire and fuels.

Activity Name	Estimated Completion	Scope of Activity	Resource Effects
Red Lodge Creek Post and Pole Unit Forest Service	2018	Harvest: 2 acres per year	Crown fire and torching will be reduced though scope of treatment is small in scale. Treatment effectiveness approximately 10 years.

Intermediate Harvest – Commercial			
Red Lodge Creek Tipi Pole Unit – Intermediate Harvest – Commercial	2018	Harvest: 2 acres per year	Crown fire and torching will be reduced though scope of treatment is small in scale. Treatment effectiveness approximately 10 years.
Ingles Creek Post and Pole Unit Forest Service Intermediate Harvest – Commercial	2015	Harvest: 2 acres per year	Crown fire and torching will be reduced though scope of treatment is small in scale. Treatment effectiveness approximately 10 years.
Christmas Bough Units Forest Service Non Commercial	2015	Treatment: 6 acres per year	Treatment consists of conifer thinning and removing ladder fuels. Reduces crown fire and torching. Slash surface fuels will deteriorate resulting in decreased surface fire hazard. Treatment effectiveness approximately 10 years.

Alternative 1 (No Action):

Under Alternative 1 No Action, no fuel treatments would occur. Existing conditions would be found in the units proposed for treatment in the action alternatives. In the absence of disturbance such as a large wildfire or bark beetle epidemic, fuel conditions would generally persist or fuel loadings would increase throughout the project area over time. The overall result would be a continuation of current fuel loadings with the associated fire behavior of significant hazard.

Direct/Indirect Effects

Surface fuels overall are considered moderate under the existing condition, but vary from stand to stand. Competition mortality, downfall as a result of numerous small beetle kill pockets, and blowdown, especially in mature trees with cankers, leads to varying loads of woody debris on the forest floor (see Table 12). Canopy densities and tree crown base heights are sufficient to support crown fire under 97th percentile weather conditions. Some units have an understory of shade tolerant conifer species establishing (Douglas fire, Engelmann spruce, and subalpine fir) that contribute to ladder fuels.

Table 12: Existing condition fire behavior fuel models for treatment units proposed in the action alternatives.

Scott and Burgan 40 Fire Behavior Fuel Models		Alternative 1 No Action	
		Existing Condition Acres	Existing Condition %
121	Grass-Shrub (Low Load)	56	3%
122	Grass-Shrub (Moderate Load)	401	22%

181	Conifer Litter (Low Load)	-	-
183	Conifer Litter (Moderate Load)	31	2%
184	Conifer Litter (Small Downed Logs)	923	50%
185	Conifer Litter (High Load)	288	16%
188	Ponderosa Pine Litter	29	1%
161	Timber (Short Understory)	46	2%
165	Timber (Tall Understory)	74	4%
Total		**1848**	**100%**

Existing condition fire behavior within the treatment units proposed under the action alternatives would be 40% crown fire. Flame lengths over 8 feet that preclude direct attack by ground resources would constitute 66% of the acreage (see Table 13). Over time, fire behavior would be expected to remain similar to the existing condition or increase slightly assuming no further disturbances occur.

Any fire that occurred in the proposed treatment area would be hard to suppress on a 97th percentile day. In the case of a landscape size wildfire, confinement to National Forest Service Lands would be unlikely. Firefighter and public safety could become compromised due to intense, unpredictable fire behavior in the wildland urban interface. Fire management suppression options would be limited due to the potential for extreme fire behavior including high flame lengths and crown fire. The potential for firebrands to land on non-NFS lands or structures would be highest under this alternative.

Table 13: Existing condition fire behavior for the treatment units proposed in the action alternatives and for the cumulative project area (no treatment).

Type of Fire	Alternative 1 No Action Proposed Treatment Units		Cumulative Project Area	
	Acres	**%**	**Acres**	**%**
Non-Burnable	-	-	130	<1%
Surface Fire	961	52%	6,434	29%
Torching Fire	155	8%	3,037	14%
Crown Fire	732	40%	12,501	57%
Flame Length (ft)				
Non-Burnable	-	-	130	<1%
0-4	223	12%	3,882	18%
4-8	414	22%	2,220	10%
8-11	460	25%	547	2%
>11	751	41%	15,323	69%
Total	**1,848**	**100%**	**22,102**	**100%**

The exception to this fire behavior scenario would be lodgepole pine stands affected by mountain pine beetle if this insect activity picked up as modeled by the combined beetle hazard in FVS. If stand and climate conditions aligned, significant mortality could occur. Fire hazard would escalate dramatically depending on post-beetle attack phase (red, gray, or old) and a wildfire in affected stands would present significant resistance to control.

If no significant disturbance were to occur, over time, a gradual replacement of lodgepole pine through natural succession by Douglas fir, Engelmann spruce, and subalpine fir is possible (Brown 1975, Lotan et al. 1985). In the near term, this process would likely increase fire potential by providing more ladder fuels that would permit a surface fire to expand into the canopy. A full change to a different forest type seems unlikely given the fire history of the Beartooth Ranger District. Effects to the fire regime if this were occur would be uncertain but a transition to more of a mixed fire regime with less intense fire behavior is possible.

Douglas fir and ponderosa pine stands would show low resiliency under the no action alternative if a significant fire were to occur. Crown fire is predicted to occur 71% of the area in these stands and flame lengths over 11 feet are predicted on 79% of the area (see Table 19). High mortality of all tree size classes would occur as a result of this fire behavior. No action would fail to accomplish all four of the fire resilient principles identified by Agee and Skinner (2005) for these forest types: (1) reduction of potential surface fire intensity, (2) reduction of potential torching by increasing height to live fuels, (3) reduction of crown bulk density to decrease potential crown fire, and (4) retain large trees in stand.

Conifer colonization, especially by Douglas fir, would continue unchecked in rangeland areas and existing limber pine stands. As rangelands areas convert to forested, a transition from surface fire to torching fire behavior would be expected (see Table 19). A gradual loss in limber pine would also be expected as these sparse stands become increasing colonized and outcompeted by Douglas fir (as observed during field visits). Over time, shading of mountain big sagebrush by trees would cause this species to deteriorate and eventually die. If a wildfire were to occur, a loss of sagebrush will naturally occur as well. Mountain big sagebrush is not fire tolerant and is easily killed by fire as this species cannot re-sprout (Young 1983, Wright et al. 1979). Post-fire establishment is restricted to seed disseminated by wind and gravity with limited viability (Noste and Bushey 1987) but big sagebrush can also reinvade quickly following fire (Young 1983). Scale of disturbance is unknown with a wildfire and cannot easily be predicted. Sagebrush re-colonization would be expected to be slower within a large wildfire area rather than if small fires affected isolated areas within the mountain big sagebrush community.

Cumulative Effects

Existing cumulative fire behavior across the project area would remain unchanged by Alternative 1 No Action. Currently the Montana DNRC Palisades Timber Sale is being harvested (work began in the winter of 2013-2014). Commercial regeneration harvest will occur on 700 acres and commercial thinning will occur on 89 acres. All harvest units will be whole tree logged and any remaining slash residues above 15 tons an acre will be mitigated. These harvests in the Burnt Fork Creek, Hogan Creek, and Thiel Creek areas will have a fire and fuels effect of substantially reducing the potential for high intensity wildfire and will complement the treatment units proposed in the Greater Red Lodge Project. Both potential crown fire and surface fire flame lengths will be reduced by the state treatments. The effect of these treatments was modeled for and is reflected in the cumulative fire behavior for the GRLA project area (see Table 21).

The Red Lodge Mountain Ski Area Vegetation Management Plan addresses treating vegetation for a variety of objectives (see cumulative effects analysis, Chapter 2). To date, 10 acres of forested land has been thinned or is proposed to be thinned on NFS lands. All slash generated by these treatments is pile burned. These treatments will help reduce the fire hazard in close proximity to ski hill development but due to the limited acreage involved, will have a small effect at the cumulative scale. Unidentified future treatments conducted under the Red Lodge Mountain Master Development Plan or new NEPA will continue to improve the fuels situation in the ski hill vicinity and make the ski hill more defensible from future wildfires.

Fire travel paths demonstrate how a fire would move through a landscape in the minimum amount of time given no fire suppression actions take place (USGS 2008). Appendix D, Figure D.1 demonstrates how fire from a lightning ignition above Red Lodge Creek would move in regards to NFS lands, private in-holdings, and private development adjacent to the forest boundary. Appendix D, Figure D.2 demonstrates how a fire from a human caused ignition at Wild Bill Lake would move. Both fires were simulated under 97th percentile weather conditions with a wind coming off the Beartooth Face or down the West Fork of Rock Creek. Under Alternative 1 No Action fire spread would move unimpeded through stands with the exception of the Montana DNRC Palisades Timber Sale harvest units.

Alternative 2 (Proposed Action), Alternative 3, and Alternative 4

All three Greater Red Lodge Project action alternatives will be addressed together for direct, indirect and cumulative effects. Alternative 2 (the Proposed Action), Alternative 3, and Alternative 4 propose to treat 1,825, 1,567, and 1,029 acres respectively. The following will be addressed for action alternatives effects to fire and fuels: effects to fuel model composition, effects to fire behavior at the treatment unit and cumulative project level, effects to the lodgepole pine forest type, effects to the Douglas fir/ponderosa pine forest types, effects to rangelands being colonized by conifers, and effects of regeneration or intermediate treatment types over time.

Direct/Indirect Effects

Through the variety of treatments proposed, all action alternatives move the units from a composition of more active fuel models capable of producing higher flame lengths and greater fireline intensity to a composition of fuel models less capable of producing intense surface fire (see Table 14). Prescribed burning would decrease timber litter and duff loads. Existing down woody debris or slash residues generated from treatment would be reduced to meet post-treatment desired fuel loadings (see post-treatment desired fuel loads, Chapter 2). This would be accomplished through piling and burning, whole tree yarding, and/or broadcast burning. Grass-shrub fuel loads would be reduced through broadcast burning but still would retain a proportion of their pre-treatment loading due to quick recovery (grasses), re-establishment of mountain big sagebrush, or burning in a mosaic where unburned areas will be retained (Young 1983), (see prescribed fire objectives, Chapter 2). Decreases in ladder fuels and a reduction in canopy bulk density through conifer removal would diminish potential for problematic fire types.

Table 14: Fire behavior fuel model composition for the proposed treatment units.

Scott and Burgan 40 Fire Behavior Fuel Models		Alternative 2				Alternative 3				Alternative 4			
		Existing Condition		Post-Treatment		Existing Condition		Post-Treatment		Existing Condition		Post-Treatment	
		Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
121	Grass-Shrub (Low Load)	56	3%	392	21%	56	4%	392	25%	56	5%	96	9%

122	Grass-Shrub (Moderate Load)	401	22%	65	4%	401	26%	65	4%	105	10%	65	6%
181	Conifer Litter (Low Load)	-	-	1,321	72%	-	-	1,056	67%	-	-	814	79%
183	Conifer Litter (Moderate Load)	27	1%	1	<1%	31	2%	1	<1%	27	3%	1	<1%
184	Conifer Litter (Small Downed Logs)	906	49%	-	-	853	54%	-	-	639	62%-	-	-
185	Conifer Litter (High Load)	286	16%	-	-	83	5%	-	-	61	6%	-	-
188	Ponderosa Pine Litter	29	2%	-	-	29	2%	-	-	27	3%	-	-
161	Timber (Short Understory)	46	3%	46	3%	53	3%	53	3%	53	5%	53	5%
165	Timber (Tall Understory)	74	4%	-	-	61	4%	-	-	61	6%	-	-
	Total	**1,825**	**100%**	**1,825**	**100%**	**1,567**	**100%**	**1,567**	**100%**	**1,029**	**100%**	**1,029**	**100%**

All three action alternatives would reduce fire behavior. The differences in effectiveness are related to the number of acres treated in each alternative and the location of the treatment areas. In general, the more acres of effective fuel reduction treatments, the lower the fire hazard and subsequent fire behavior characteristics. The three action alternatives were contrasted against the total possible treatment acres or treatment footprint to provide a method of comparison between alternatives. As acreage of treatment decreases for a particular alternative, the fire behavior of the untreated ground is captured as well as the fire behavior for the treated ground (see Table 15). Acres of torching or crown fire are more pronounced for Alternative 4 compared to Alternatives 2 or 3. Flame lengths above 8 feet, which preclude direct attack by suppression ground resources, are also more pronounced for Alternative 4. Alternatives 2 and 3 are very similar in regards to their acres by fire type or flame length.

Table 15: Fire behavior comparison between alternatives for proposed treatment units.

	Alternative 1 No Action		Alternative 2		Alternative 3		Alternative 4	
Fire Type	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Surface Fire	961	52%	1,829	99%	1,771	96%	1611	87%
Torching Fire	155	8%	-	-	-	-	42	2%
Crown Fire	732	40%	19	1%	77	4%	195	11%
Flame Length (ft)								
0-4	223	12%	1,168	63%	1,007	54%	883	48%
4-8	414	22%	502	27%	624	34%	319	17%
8-11	460	25%	136	8%	140	8%	451	11%
>11	751	41%	42	2%	77	4%	195	24%
Total	**1,848**	**100%**	**1,848**	**100%**	**1,848**	**100%**	**1,848**	**100%**

Note: Action alternatives were compared against the Alternative 1 No Action acres. Acres not treated by action alternatives where figured into fire behavior outputs for each action alternative.

Alternatives 3 and 4 propose substantially less treatment in the mature or overmature lodgepole pine than Alternative 2. Many of the forested units that were excluded from treatment between action alternatives were lodgepole stands. The benefit of managing these mature or overmature stands is not captured in Alternatives 3 and 4 as demonstrated by the reduction of approximately 300 to 400 acres of surface fire behavior (see Table 16). A substantial percentage of this untreated area is prone to crown fire and flame lengths greater than 11 feet. Broadcast burning is prescribed for approximately one quarter of the regeneration treatments in the lodgepole. The remainder of the regeneration treatments and all of the thinning treatments in this forest types will be pile burned.

Through a combination of thinning or regeneration treatments, fire behavior would be greatly reduced in mature and overmature lodgepole stands. A buildup of ground fuels and the establishment of shade tolerant conifer species in overmature stands provide the surface fire intensity necessary to often initiate crown fire (Brown 1975, Lotan et al. 1985). Shade tolerant species such as Douglas fir and Engelmann spruce are much more flammable than other understory vegetation (Brown 1975). Removal of ground fuels, thinning shade tolerant species, and removing tree crowns from the forest canopy substantially reduces crown fire in these stands.

Table 16: Fire Behavior in mature or overmature lodgepole pine forest type units.

	Alternative 1 No Action		Alternative 2		Alternative 3		Alternative 4	
Fire Type	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Surface Fire	368	40%	919	100%	649	100%	515	100%
Torching Fire	20	2%	-	-	-	-	-	-
Crown Fire	531	58%	-	-	-	-	-	-
Flame Length (ft)								
0-4	114	12%	838	91%	582	90%	470	91%
4-8	254	28%	22	2%	29	4%	7	1%
8-11	-	-	36	4%	38	6%	38	8%
>11	551	60%	23	3%	-	-	-	-
Total	**919**	**100%**	**919**	**100%**	**646**	**100%**	**515**	**100%**

Note: Acres and percentages are only for the ground treated by an alternative. Acres not included for a particular action alternative would have the existing condition fire behavior.

Young, dense stands of lodgepole also present high fire hazard (Brown 1975 and Lotan et al. 1985), (see Table 17). Non-commercial thinning and non-commercial stand regeneration is proposed for dense, immature stands of lodgepole found in old clearcuts and a fire scar from the 1970's. Thinning these stands by hand or mechanically by mastication will greatly reduce aerial fuels associated with high intensity fire behavior. Non-commercial stand regeneration is proposed when intense tree-to-tree competition has resulted in severely suppressed stand structures that thinning is unlikely to improve.

Table 17: Fire Behavior in young, dense lodgepole pine forest type units.

	Alternative 1 No Action		Alternative 2		Alternative 3		Alternative 4	
Fire Type	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Surface Fire	22	23%	95	100%	99	100%	74	100%
Torching Fire	-	-	-	-	-	-	-	-
Crown Fire	73	77%	-	-	-	-	-	-

Flame Length (ft)								
0-4	22	23%	95	100%	99	100%	74	100%
4-8	-	-	-	-	-	-	-	-
8-11	-	-	-	-	-	-	-	-
>11	73	77%	-	-	-	-	-	-
Total	**95**	**100%**	**95**	**100%**	**99**	**100%**	**74**	**100%**

Note: Acres and percentages are only for the ground treated by an alternative. Acres not included for a particular action alternative would have the existing condition fire behavior.

The amount of acreage proposed for treatment in Douglas fir and ponderosa pine forest types does not fluctuate greater between any of the action alternatives. A substantial reduction of crown fire and an increase in flame lengths less than four feet (compared to the higher flame length categories) will have marked effects to the resiliency of these stands (see Table 18). Broadcast burning is proposed for 54% these treatments under the proposed action.

All treatments proposed in this forest type are intermediate treatments utilizing thinning from below silviculture prescriptions. Omi et al. (2007) identified that effective fuel treatment in dry forest types should decrease canopy bulk density, raise canopy base height, and increase average tree diameter. The proposed treatments will meet these criteria. Additionally, these treatments will aid in buffering the forest boundary and improving suppression options similar to the findings Omi et al. (2007) presented through their case study of fuel treatments tested by five large wildfires in these forest types.

Table 18: Fire Behavior in Douglas fir and ponderosa pine forest type units.

	Alternative 1 No Action		**Alternative 2**		**Alternative 3**		**Alternative 4**	
Fire Type	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Surface Fire	29	21%	137	100%	137	100%	127	100%
Torching Fire	-	-	-	-	-	-	-	-
Crown Fire	108	79%	-	-	-	-	-	-
Flame Length (ft)								
0-4	-	-	108	79%	108	79%	100	79%
4-8	29	21%	29	21%	29	21%	27	21%
8-11	-	-	-	-	-	-	-	-
>11	108	79%	-	-	-	-	-	-
Total	**137**	**100%**	**137**	**100%**	**137**	**100%**	**127**	**100%**

Note: Acres and percentages are only for the ground treated by an alternative. Acres not included for a particular action alternative would have the existing condition fire behavior.

Rangeland conifer colonization treatments affect fire behavior by eliminating torching on areas that have become heavily forested. Reducing shrub and grass loads through broadcast burning shifts flame lengths to less than 8 feet, allowing direct attack by ground resources (see Table 19).

Considerably less conifer colonization treatment is proposed in Alternative 4 compared to Alternatives 2 and 3. Four proposed units that were excluded from treatment in the West Fork of Rock Creek under Alternative 4 decreased the GRLA project conifer colonization treatment by close to 60%. This is significant because 59% of the dropped units have already experienced some degree of conifer colonization. Also lost in Alternative 4, by excluding these treatments, is the opportunity to re-introduce fire to these lands through prescribed burning.

Current high shrub densities, especially in rangeland units proposed in the West Fork Rock Creek area, could encourage conifer colonization and the eventual loss of mountain big sagebrush. Heyerdahl et al. (2006) found that Douglas fir establishment immediately following fire was likely limited by low shrub density because this conifer prefers shaded microsites to establish seedlings. The existing condition may be encouraging conifer colonization by providing receptive sites for Douglas fir seedlings to get established. As rangelands continue to be colonized by conifers, big mountain sagebrush can be lost as a conifer canopy develops (Heyerdahl et al. 2006). Finally, high shrub densities expose these sites to the potential of a large wildfire that would burn most of the area. Prescribed burning during carefully selected weather and fuel moisture conditions provide the opportunity to burn in a mosaic and leave unburned areas of mature sagebrush and create more overall heterogeneity.

Table 19: Fire Behavior for conifer colonization rangeland units.

	Alternative 1 No Action		Alternative 2		Alternative 3		Alternative 4	
Fire Type	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Surface Fire	35	6%	170	27%	176	28%	103	40%
Torching Fire	135	22%	-	-	-	-	-	-
Crown Fire	-	-	-	-	-	-	-	-
Non-Forested Surface Fire*	449	72%	449	73%	449	72%	153	60%
Flame Length (ft)								
0-4	35	6%	68	11%	68	11%	68	27%
4-8	124	20%	451	73%	455	73%	113	44%
8-11	460	74%	100	16%	102	16%	75	29%
>11	-	-	-	-	-	-	-	-
Total	**619**	**100%**	**619**	**100%**	**625**	**100%**	**256**	**100%**

*Non-forested acres would have a fire type of surface fire before or after any treatments.
Note: Acres and percentages are only for the ground treated by an alternative. Acres not included for a particular action alternative would have the existing condition fire behavior.

Both regeneration and intermediate treatments are effective at reducing fire hazard. Both treatment types reduce all crown fire and torching to surface fire post-treatment. Regeneration treatments show a slight advantage in reducing flame lengths. Intermediate treatments fail to reduce flame lengths to less than 8 feet on approximately 10% of the treated ground (see Table 20). Prescribed fire is included in both regeneration and intermediate treatments depending on stand type.

Table 20: Fire behavior for regeneration and intermediate treatment treatments.

	Alternative 1 No Action				Alternative 2				Alternative 3				Alternative 4			
	Regen		**Inter**		**Regen**		**Inter**		**Regen**		**Inter**		**Regen**		**Inter**	
Fire Type	**Ac**	**%**	**Ac**	**%**	**Ac**	**%**	**Ac**	**%**	**Ac**	**%**	**Ac**	**%**	**Ac**	**%**	**Ac**	**%**
Surface Fire	245	45%	216	28%	547	100%	781	100%	349	100%	712	100%	231	100%	588	100%
Torching Fire	20	4%	135	17%	-	-	-	-	-	-	-	-	-	-	-	-
Crown Fire	282	51%	430	55%	-	-	-	-	-	-	-	-	-	-	-	-
Flame																

Length (ft)																
0-4	40	7%	131	17%	524	96%	592	76%	349	100%	508	71%	231	100%	481	82%
4-8	205	38%	153	20%	-	-	118	15%	-	-	129	18%	-	-	59	10%
8-11	-	-	67	8%	-	-	71	9%	-	-	75	11%	-	-	48	8%
>11	302	55%	430	55%	23	4%	-	-	-	-	-	-	-	-	-	-
Total	**547**	**100%**	**781**	**100%**	**547**	**100%**	**781**	**100%**	**349**	**100%**	**712**	**100%**	**231**	**100%**	**588**	**100%**

Note: Acres and percentages are only for the ground treated by an alternative. Acres not included for a particular action alternative would have the existing condition fire behavior.

An examination of how regeneration treatments differ from intermediate treatments over time shows that regeneration treatments do have more longevity on the landscape. For this comparison flame length is the appropriate fire behavior metric to use because of significant differences in stand developmental stages make crown fire meaningless (although both treatments did model at least 80% surface fire by the year 2052). Immediately post-treatment (year 2022), both regeneration and intermediate harvests reduce flame lengths generally to less than 4 feet (see Figure 5). By the year 2052, regeneration treatments have flame lengths greater than 8 feet on 15% of the area whereas intermediate treatments produce flame lengths greater than 8 feet on approximately 50% of the ground (see Figure 6).

The reason for this longevity of regeneration treatment is due to understory conifer species establishing in intermediate treatments. Also, changes in fuel models due to canopy mortality affect fire behavior. As a modeling tool, FVS is able to capture both of these stand changes overtime. There are a multitude of reasons why regeneration or intermediate treatments may be appropriate for the Greater Red Lodge Project (see other resource reports), but solely from a fire behavior perspective, regeneration treatments are preferable.

Alternatives 3 and 4 propose 36% and 58% less regeneration treatments than Alternative 2 (see Table 20). Intermediate treatments proposed by Alternatives 3 and 4 are 9% and 25% less than Alternative 2. By proposing substantially more regeneration treatments, Alternative 2 will undoubtedly have more longevity on the landscape. Alternatives 3 and 4 each present marked step-downs in benefit from Alternative 2 over time.

Figure 5: Flame length comparison between regeneration and intermediate treatments post-treatment, year 2022.

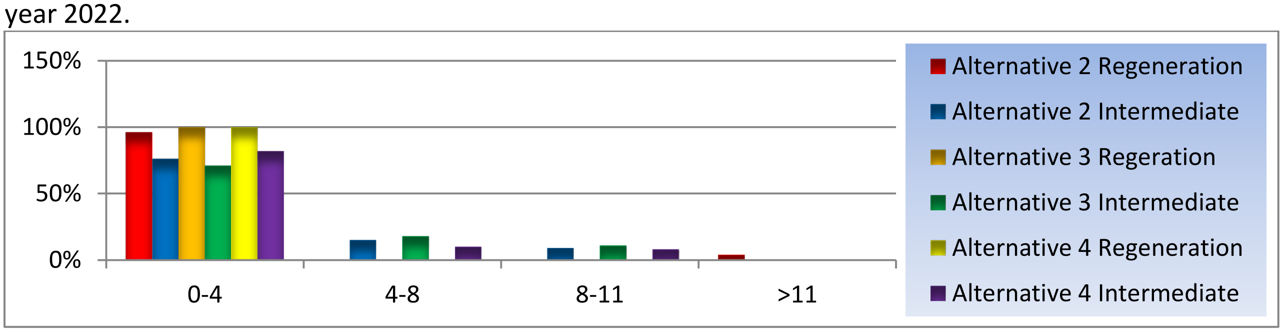
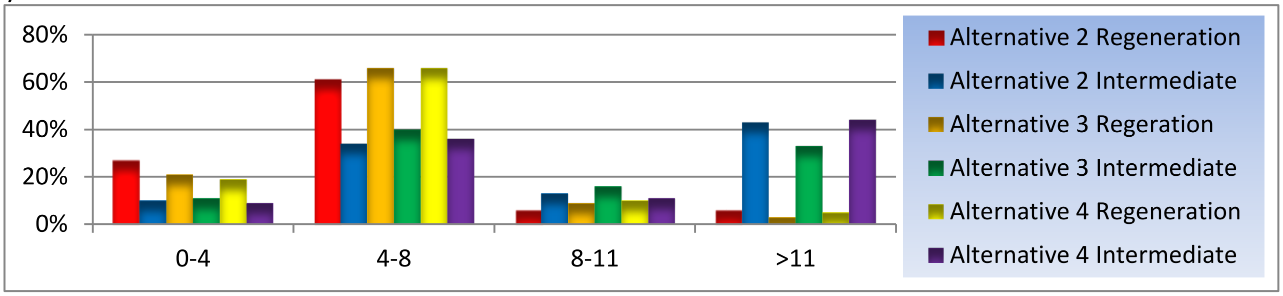


Figure 6: Flame length comparison between regeneration and intermediate treatments post-treatment, year 2052.



Cumulative Effects

The change in percent of cumulative fire behavior is insignificant either compared between action alternatives or compared against the no action alternative. Alternatives 2, 3, and 4 reduce metrics such as crown fire and flame lengths greater the 11 feet by 3%, 2%, and 1% respectively (see Table 21). As stated throughout this proposal, the ability to affect change across the broader Greater Red Lodge Project landscape is limited. A lack of roads and steep, inaccessible terrain make treatment unfeasible. Fire behavior higher on the Beartooth Face will remain unchanged by any of the action alternatives and would still be capable of supporting high intensity fire. What this highlights is the need to treat in the Wildland Urban Interface adjacent of the NFS lands boundary to meet the purpose and need for action of the project.

Current fuel conditions are capable of producing torching or crown fire behavior across approximately 70 percent of the Beartooth Face during high fire danger. Flame lengths greater than 11 feet account for more than 65 percent of this fire behavior. The fire effects this modeled fire behavior would produce closely match what fire management and BAER teams have observed after large, landscape fires on the Beartooth Ranger District.

Table 21: Cumulative fire behavior for all alternatives.

	Alternative 1 No Action		**Alternative 2**		**Alternative 3**		**Alternative 4**	
Fire Type	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Non-Burnable	130	<1%	130	<1%	130	<1%	130	<1%
Surface Fire	6,434	29%	7,312	33%	7,126	32%	6,859	31%
Torching Fire	3,037	14%	2,769	13%	2,800	13%	2,824	13%
Crown Fire	12,501	57%	11,891	54%	12,095	55%	12,360	56%
Flame Length (ft)								
Non-Burnable	130	<1%	130	<1%	130	<1%	130	<1%
0-4	3,882	18%	5,608	25%	5,423	24%	5,332	24%
4-8	2,220	10%	1,538	7%	1,556	7%	1,305	6%
8-11	547	2%	193	1%	196	1%	274	1%
>11	15,323	69%	14,633	66%	14,846	67%	15,132	68%
Total*	**22,102**	**100%**	**22,102**	**100%**	**22,151**	**100%**	**22,173**	**100%**

*Acreage totals vary <1% between alternatives due to rounding and limitations of working with pixelated data.

Utilizing the Minimum Travel Time tool in FlamMap 5.0, an analysis was conducted for how long it would take for two fires in the fuels cumulative project area to burn from their origins to two identified areas of values-at-risk. The simulations were also meant to provide a means of comparison for the effect the action alternatives would have on these fire travel times. The unit of measure for comparison was the percent increase in time it would take for the fires to travel from their origin to the values-at-risk.

Simulations of two 5 acre fires that had escaped initial attack suppression efforts were conducted, one for a lightning strike on the Beartooth Face above Red Lodge Creek and one from a human ignition in the Wild Bill Lake area in the West Fork Rock Creek. For the Red Lodge Creek Fire, the values-at-risk area was the Sheep Mountain Subdivision. For the West Fork Rock Creek Fire, the values-at risk area was a concentration of structures in the West Fork Rock Creek south of Palisades Campground.

The results for the minimum travel time analysis were significant between the action alternatives for the Red Lodge Creek Fire (Table 22). Alternatives 2, 3, and 4 modeled percent increases in travel time of 64%, 52%, and 32% respectively. The differences in travel times were not as significant for the West Fork Rock Creek Fire. Alternatives 2, 3, and 4 modeled percent increases in travel times of 15%, 4%, and 0% respectively. The reason for this reduced treatment effect regarding travel times in the West Fork Rock Creek has to do with the difference in treatment acres of grass-shrub fuel types. Even post-treatment, rates of spread in grass-shrub fuel types can be moderate. The benefit of treatments in this fuel type is reduced intensity through reduced flame length (see Table 19). This reduction in intensity benefits suppression efforts by decreasing the resistance to control. Also, treatment in the grass-shrub fuel types target reducing conifer colonization, another benefit not captured in this minimum travel time analysis.

Table 22: Minimum travel time analysis of two wildfires to values at risk.

		Minimum Travel Time for a developing landscape wildfire (hours)						
		Alternative 1 No Action	Alternative 2		Alternative 3		Alternative 4	
FlamMap Ignition	Value-at-Risk	MTT	MTT	Percent Increase in Time	MTT	Percent Increase in Time	MTT	Percent Increase in Time
Lightening Ignition on the Beartooth Face above Red Lodge Creek	Sheep Mountain Subdivision	27.9	45.8	64%	42.4	52%	36.9	32%
Human Ignition at Wild Bill Lake	West Fork Rock Creek Structures	10.9	12.5	15%	11.3	4%	10.9	0%

Fire travel paths depict how the proposed treatment units of the different action alternatives would align with fire movement through the landscape. Travel paths for the same simulated fires as the minimum travel time analysis are displayed for each of the action alternatives (see Appendix D, Figures D.3, D.4, D.5, D.6, D.7, and D.8). By placing treatment units within these corridors, fire behavior would be modified by altering crown fire activity and decreasing flame lengths by forcing a fire to flank around treated areas (Finney 2001). Less treatment proposed by Alternative 4 would reduce this break up effect of head fire runs in different areas of the project.

Cumulative effects of DNRC Palisades Timber Sale and treatment associated with the Red Lodge Mountain Ski Area Vegetation Management Plan remain the same as identified under cumulative effects for Alternative 1 No Action.

Summary of Action Alternatives

By proposing the most acreage treated by the most intensive treatment types (regeneration compared to intermediate), Alternative 2 reduces the most area of high fire hazard on the landscape and provides the most fuels reduction benefit over time. Most fire travel corridors have treatment units placed to reduce large, un-interrupted head fire runs.

Alternative 2 and 3 appear very similar in acreage of low fire behavior hazard for all the proposed treatment units, however, subtleties emerge between the two alternatives when looking at treated acres in the lodgepole pine forest type and the amount of regeneration harvest or intermediate harvest. Many of the acres excluded from treatment in Alternative 3 were lodgepole regeneration or aspen regeneration treatments. The effect is a reduction of treatment in lodgepole stands that are currently mature or overmature. Nearly 200 acres or 36% less regeneration treatment is proposed by Alternative 3. This will have a proportional effect over time in the fuels treatment zone. Percent increase in travel times for the two simulated wildfires were notably different between these two alternatives (see Table 22). Also, an examination of the untreated area in the 8T and 23F unit vicinity raises concern of a fire travel corridor to private lands under this alternative. The consequence of having this corridor on the landscape may be minor considering the amount of treatment adjacent to this possible travel path.

Alternative 4 proposes significantly less treatment and therefor, significantly less area of positive fire behavior effects. This is reflected by the reduced acreage of low fire hazard in all the stand types and rangelands. Treatment longevity is also greatly reduced because of substantially less regeneration treatment compared to the other two action alternatives. Alternative 4 is only comparable to the other action alternatives for its area of positive fire behavior effects in the Douglas fir and ponderosa pine forest types. Percent increase in travel times for the two simulated wildfires was significantly reduced under Alternative 4 (there was no travel time increase for the West Fork Rock Creek Fire simulation, see Table 22). Multiple untreated corridors exist under this alternative that could serve as travel paths to large wildfires.

Irreversible/Irretrievable Commitments

Even if an action alternative is implemented, a rapidly developing wildfire may impact private lands adjacent to the NFS lands boundary. Despite increased suppression options and decreased fire behavior within the proposed treatment units, severe conditions may produce enough extreme fire behavior to evade the best suppression actions. However, under existing conditions, a rapidly developing wildfire is very likely going to impact private lands adjacent to the NFS boundary. Suppression actions to confine or contain a fire of this nature are going to occur primarily on private property where vegetation conditions allow for more effective uses of suppression resources. In short, many of the impacts described in the Wildland Urban Interface section of this report are going to be realized.

The extensive lodgepole pine stands in the Greater Red Lodge Project Area are accumulating down woody debris as a result of suppression mortality, mountain pine beetle attacks, and windthrow. Shade tolerant species are also establishing as a common understory. These traits vary by stand and not all stands have substantial fuel accumulations or conifer understories yet. However, lodgepole age classes in sampled stands across the project area are very similar and these effects can be expected to continue with time (see silviculture report). Both of these traits are typical of overmature stands and as they continue to manifest, produce high fire potential (Brown 1975, Lotan et al. 1985). Additionally, widespread mountain beetle activity is possible if stand and weather conditions align. By not acting to alleviate these conditions, fire hazard on NFS lands adjacent to the forest boundary can only be expected to increase in the future.

Existing conditions could easily support a large wildfire that would have high severity effects in Douglas fir and ponderosa pine stands. With the right weather and fuel moisture conditions, a wildfire is capable of inducing substantial mortality in these stands. A high severity fire is also capable of reducing or eliminating the seed stock of these species and preferring a predominance lodgepole pine (Brown 1975, Lotan et al. 1985). The result would be a loss in stand diversity and richness in the fuels treatment zone.

Rangeland treatment benefits limber pine stand health by reducing competition from Douglas fir and by creating sites favorable to seedling establishment. Without intervention, limber pine are susceptible to further degradation or loss through continued Douglas fir establishment or a high severity wildfire event in heavily colonized stands. Many dying and recently dead limber pine were observed in the proposed units. This species is suffering the effects of mountain pine beetle attacks and blister rust across the Beartooth Ranger District. Significant mortality caused by a high severity wildfire would further reduce cone producing trees and limit or eliminate natural regeneration. Over time, further reductions in limber pine occurrence could be expected without management.

Conifer colonization also has negative impacts to big mountain sage brush as well. Continued colonization would eliminate sagebrush from areas where a significant conifer canopy establishes (Heyerdahl et al. 2006). Late seral stands of sagebrush are exposed to wildfires burning a high proportion of their area and causing near total mortality. Natural re-colonization would be very slow. Carefully executed broadcast burning presents the opportunity to create heterogeneity in the form of age class diversity that would resist future wildfires burning an entire stand.

Forest Plan Consistency of Alternative 1 (No Action)

Alternative 1 No Action would not take any measures to protect human life and property within or adjacent to the NFS lands from uncontrolled and unwanted wildfire. The no action alternative would not use prescribed fire to help meet the goals of the Management Areas within the analysis area. It would not develop cost effective fire programs because it is reasonable to expect more intense fire behavior than in treated stands, thus control would be more difficult and likely require a greater number and type of suppression resources. For these combined reasons, Alternative 1 No Action is not consistent with Custer Forest Plan goals, objectives, and standards.

Action Alternatives 2, 3, and 4

Action alternatives proposed as part of the Greater Red Lodge Project are consistent with Forest Plan Standards related to fire and fuels management. Specifically the project purpose and need for hazardous fuels reduction is responsive to the forest-wide standard to implement plans that consider threats to life and property, public safety, and resource values. Alternatives 2 and 3 best meet this purpose and need. As discussed below, it is questionable whether Alternative 4 fully meets this purpose and need due to the large reduction in acres treated. See also – Response to Comments 87, 88, and 106.

Conclusions

The opportunity to reduce fire hazard in the Wildland Urban Interface is best provided by Alternative 2, the proposed action. When related back to the hazardous fuels need for action, Alternative 2 would provide the greatest reduction of high intensity wildfire in the WUI, provide the safest environment for the public and firefighters should a wildfire occur, and provide wildfire managers the most flexibility of suppression options.

Alternative 3, though reduced, would still provide many of the benefits of Alternative 2. The greatest tradeoff is the amount of acreage of lodgepole pine stands left untreated in the WUI. Overtime, these stands would continue to mature and either build significant surface fuel loads or develop shade tolerant understories that would increase fire hazard.

It is questionable whether Altenative 4 meets the hazardous fuels need for action. Terrain that is suitable for treatment along the Beartooth Face is limited. The broader landscape of the GRLA project area will remain untreated at higher elevations and the potential for large, landscape size wildfires will remain no matter which proposed action alternative may possibly be implemented. Precisely due to this reality, every opportunity to treat along the boundary of NFS lands must be capitalized upon. Much ground that is accessible for treatment is excluded from this alternative. A fire moving from higher on the Beartooth Face could move more easily through the fuels treatment zone under Alternative 4. It also must not be forgotten that 51% of our wildfires are caused from human ignitions. Many of these human ignitions occur adjacent to campgrounds, at dispersed campsites, or along roads in close proximity to the forest boundary. By leaving a greater percentage of these forest boundary lands untreated, Alternative 4 provides more opportunity for a fire to develop to considerable size and intensity in what otherwise would have likely been treated through implementation of Alternatives 2 or 3.

Resiliency, from a fire and fuels perspective, would be increased to the greatest degree through implementation of Alternatives 2 or 3. Both of these alternatives provide approximately the same amount of treatment in Douglas fir and ponderosa pine stands and the same amount of conifer colonization reduction and prescribed burning in rangelands. Alternative 4 provides less resiliency by excluding 10 acres of treatment in the dry forest types and 363 acres of treatment in the conifer colonized rangelands. Alternative 4 also has less broadcast burning proposed. Returning fire to the ecosystem as an important disturbance process has been cited as important step in restoring ecological resiliency.

Lastly, past fuel treatments that have been implemented on the Beartooth Ranger District have had positive effects on local suppression actions. These treatments were similar in nature to the treatments being proposed in the Greater Red Lodge Project. Both large, landscape wildfires and small initial attack wildfires have had their impacts reduced by Beartooth treatments. Implemented fuels treatments have affected suppression decisions and operations that saved structures (Cascade Fire), been used as fireline anchor points and for conducting burnout operations (Rock Creek Fire), and reduced intensity of initial attack wildfires that occurred within treated areas. These realized benefits are directly related to what was identified as the hazardous fuels need for action of this project.

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Appendix A

Glossary

Please note: many of these definitions are available at the NWCG website (2012) www.nwcg.gov/pms/pubs/glossary/glossary.htm.

active crown fire – a crown fire in which the entire fuels complex becomes involved but the crowning phase remains dependent on heat released from surface fuel for continued spread.

aspect – the cardinal direction in which a slope faces.

canopy base height – for modeling in BehavePlus, canopy base height refers to understory ladder fuels and the main canopy layer for a stand of trees.

canopy bulk density – mass of available canopy fuel per unit canopy volume of a stand.

coarse woody debris – dead wood greater than 3 inches in diameter or 1000-hr timelag fuels.

conditional crown fire – a fire that burns as a crown fire if it enters the stand as a crown fire from an adjacent stand.

critical surface intensity – surface fire intensity needed to transition to a crown fire.

crown fire – a fire that spreads in the canopy of trees or shrubs more or less independent of a surface fire.

energy release component (ERC) – the total heat release within the flaming front at the head of a moving fire. ERC relies on large and live fuels, has low variability, and is not affected by wind speed. It is used to characterize seasonal fire danger based on an area's moisture conditions.

fine woody debris – dead wood less than 3 inches in diameter or 1-, 10-, and 100-hr timelag fuels.

fire behavior fuel model – a cohesive set of parameters that define the necessary inputs to the fire spread model.

fire frequency – a general term referring to the recurrence of fire in a given area over time.

fire intensity – the energy output produced by a fire. Specifically, fireline intensity is measured as the rate of heat release per unit time per unit length of fire front.

fire regime – the nature of fire on the landscape over time. Also further described by characteristics such as how often a landscape may burn, the common size of fires, and the severity of how fires typically burn.

fire return interval – the time between two successive fires of approximately the same nature (approximate size and severity) in a specified area.

fire severity – the degree to which a site has been altered by fire; loosely, a product of fire intensity and residence time.

fire type – surface (S), torching (T, [passive crown fire}), or crowning (C, [active crown fire])

flame length – within the flaming front, the length of the flame of a spreading surface fire; a function of fire intensity that influences the effect on vegetation.

foliar moisture – moisture content of overstory foliage; one of the attributes used to determine transition from surface to crown fire; 100% refers to mature foliage with new growth complete.

intermediate treatment – cutting only a portion of the trees in a stand. These treatments are meant to enhance growth, quality, vigor, and composition of a stand. A new age class of trees is not established by this treatment.

ladder fuels – fuels that provide vertical continuity between surface and canopy fuels; an example would be conifer seedlings and saplings.

midflame windspeed – the windspeed at midflame height above the fuelbed; also referred to as eye-level winds.

passive crown fire – see torching.

regeneration treatment – all the trees are cut in the treated area of a stand (although small reserve islands of trees can be retained). A new age class of trees is established by this treatment.

residence time – the total length of time that the flaming front of the fire occupies one point.

scorch height – height above the ground that the temperature in the convection column reaches the lethal temperature to kill live crown foliage.

slope - the ratio between the amount of vertical rise of a slope and horizontal distance as expressed in a percent.

spotting – embers that are transported ahead of the zone of direct ignition of the main fire that start new fires.

surface fire – a fire that burns close to the ground surface including dead branches, leaves, and low vegetation.

torching – a fire that burns a single tree or group of trees, also known as passive crown fire.

twenty-foot winds – wind speed and direction at 20 feet above the height of the top of the vegetation.

wind adjustment factor – adjusts the 20-ft windspeed to midflame windspeed depending on the sheltering of fuels from the wind.

0.1 - fully sheltered, dense stands
0.2 - fully sheltered, open stands
0.3 - partially sheltered
0.4 – unsheltered

Appendix B

Treatment units assigned Anderson 13 fuel models and Scott and Burgan 40 fuel model crosswalk.

Assigned Anderson 13 Fire Behavior Fuel Models, weighted by percent		Scott and Burgan 40 Fire Behavior Fuel Models crosswalk equivalent		Alternative 1 No Action		Alternative 2		Alternative 3		Alternative 4	
				Acres	%	Acres	%	Acres	%	Acres	%
1(100%)	Grass	121	Grass-Shrub (Low Load)	56	3%	384	21%	384	25%	88	9%
1(65%), 8(35%)	Grass, Timber Litter	121	Grass-Shrub (Low Load)	-	-	8	<1%	8	1%	8	1%
2(75%), 1(25%)	Grass-Shrub, Grass	122	Grass-Shrub (Moderate Load)	393	21%	65	4%	65	4%	65	6%
2(65%), 8(25%), 10(10%)	Grass-Shrub, Timber Litter, Timber Understory	122	Grass-Shrub (Moderate Load)	8	<1%	-	-	-	-	-	-
1(75%), 8(15%), 9(10%)	Grass, Timber Litter, Long-Needle/Hardwood Litter	181	Conifer Litter (Low Load)	-	-	29	2%	29	2%	27	3%
8(100%)	Timber Litter	181	Conifer Litter (Low Load)	-	-	1,006	55%	944	60%	726	70%
8(90%), 5(10%)	Timber Litter, Brush	181	Conifer Litter (Low Load)	-	-	286	15%	83	5%	61	6%
8(100%)	Timber Litter	183	Conifer Litter (Moderate Load)	25	1%	1	<1%	1	<1%	1	<1%
8(75%), 10(25%)	Timber Litter, Timber Understory	183	Conifer Litter (Moderate Load)	6	<1%	-	-	-	-	-	-
8(65%), 10(35%)	Timber Litter, Timber Understory	184	Conifer Litter (Small Downed Logs)	296	16%	-	-	-	-	-	-
8(50%), 10(50%)	Timber Litter, Timber Understory	184	Conifer Litter (Small Downed Logs)	627	34%	-	-	-	-	-	-
8(45%), 10(45%), 5(10%)	Timber Litter, Timber Understory, Brush	185	Conifer Litter (High Load)	288	16%	-	-	-	-	-	-
2(75%), 8(15%), 9(10%)	Grass-Shrub, Timber Litter, Long-Needle/Hardwood Litter	188	Ponderosa Pine Litter	29	2%	-	-	-	-	-	-
10(75%), 8(25%)	Timber Understory, Timber Litter	165	Timber (Tall Understory)	9	<1%	-	-	-	-	-	-
10(100%)	Timber Understory	165	Timber (Tall Understory)	38	2%	-	-	-	-	-	-
10(50%), 8(30%), 12(20%)	Timber Understory, Timber Litter, Slash	165	Timber (Tall Understory)	27	1%	-	-	-	-	-	-
9(75%), 8(25%)	Long-Needle/Hardwood Litter, Timber Litter	161	Timber (Short Understory)	-	-	-	-	7	<1%	7	1%
5(50%), 1(25%), 2(25%),	Brush, Grass, Grass-Shrub	161	Timber (Short Understory)	46	2%	46	3%	46	3%	46	4%

Total	**1848**		**1825**		**1567**		**1029**	

Appendix C

Cumulative project strata assigned Anderson 13 fire behavior fuel models.

Strata Cover Type and Cover Class	Strata Number	Assigned Anderson 13 Fire Behavior Fuel Models, weighted by percent		Greater Red Lodge Project Area Acres	%
ABLA–10 to 60%+	1	8(40%), 10(35%), 5(25%)	Timber Litter, Timber Understory, Brush	86	<1%
PICO– 60%+	2	8(50%), 10(50%)	Timber Litter, Timber Understory	2,658	17%
PICO–10 to 24.9%	3	8(45%), 10(45%), 5(10%)	Timber Litter, Timber Understory, Brush	134	1%
PICO–25 to 39.9%	4	8(45%), 10(45%), 5(10%)	Timber Litter, Timber Understory, Brush	1,452	10%
PICO–40 to 59.9%	5	8(50%), 10(50%)	Timber Litter, Timber Understory	6,927	45%
PIEN–60% +	6	8(50%), 10(50%)	Timber Litter, Timber Understory	240	2%
PIEN–10 to 59.9%	7	8(40%), 10(35%), 5(25%)	Timber Litter, Timber Understory, Brush	273	2%
PIFL–25 to 60% +	8	8(65%), 10(35%)	Timber Litter, Timber Understory	577	4%
PIFL–10 to 24.9%	9	8(50%), 10(25%), 1(25%)	Timber Litter, Timber Understory, Grass	244	2%
PIPO–10 to 39.9%	10	2(50%), 8(25%), 10(25%)	Grass-Shrub, Timber Litter, Timber Understory	46	<1%
PSME– 60%+	11	8(50%), 10(50%)	Timber Litter, Timber Understory	290	2%
PSME–10 to 24.9%	12	2(50%), 8(25%), 10(25%)	Grass-Shrub, Timber Litter, Timber Understory	189	1%
PSME–25 to 39.9%	13	2(50%), 8(25%), 10(25%)	Grass-Shrub, Timber Litter, Timber Understory	287	2%
PSME – 40 to 59.9%	14	8(40%), 10(35%), 2(25%)	Timber Litter, Timber Understory, Grass-Shrub	1875	12%
			Total	**15278**	**100%**

Appendix D

Figure D.1: Alternative 1 No Action lightning ignition wildfire travel path in the Red Lodge Creek area.

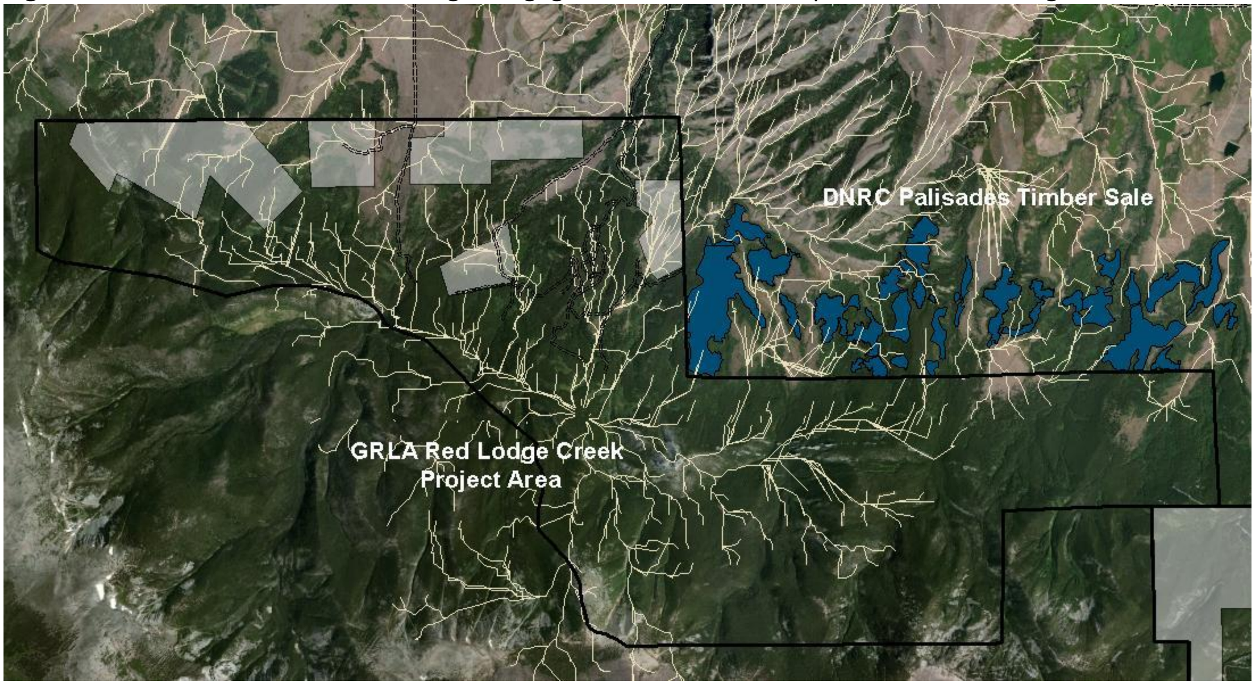


Figure D.2: Alternative 1 No Action human ignition wildfire travel path in the West Fork Rock Creek area.

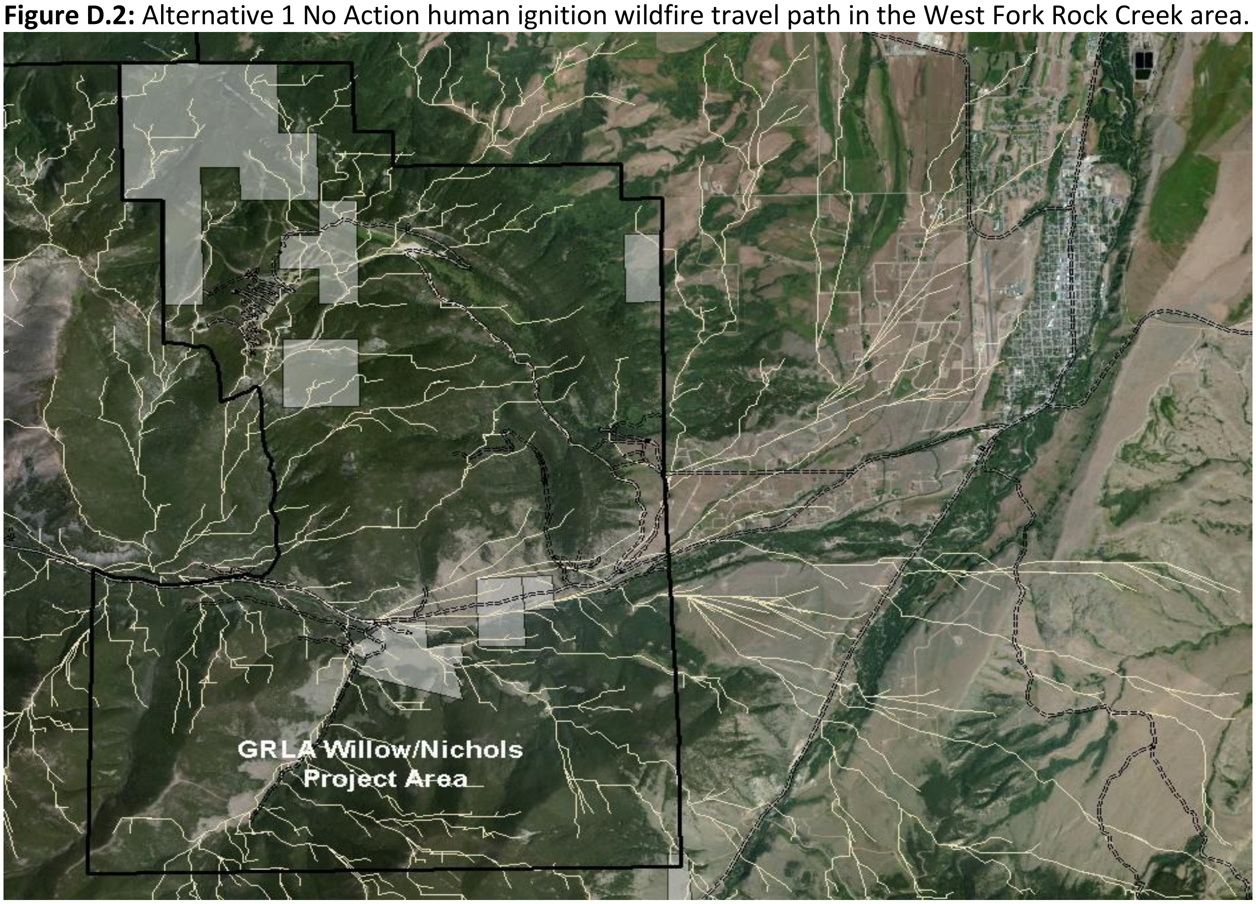


Figure D.3: Alternative 2 lightning ignition wildfire travel path in the Red Lodge Creek area.

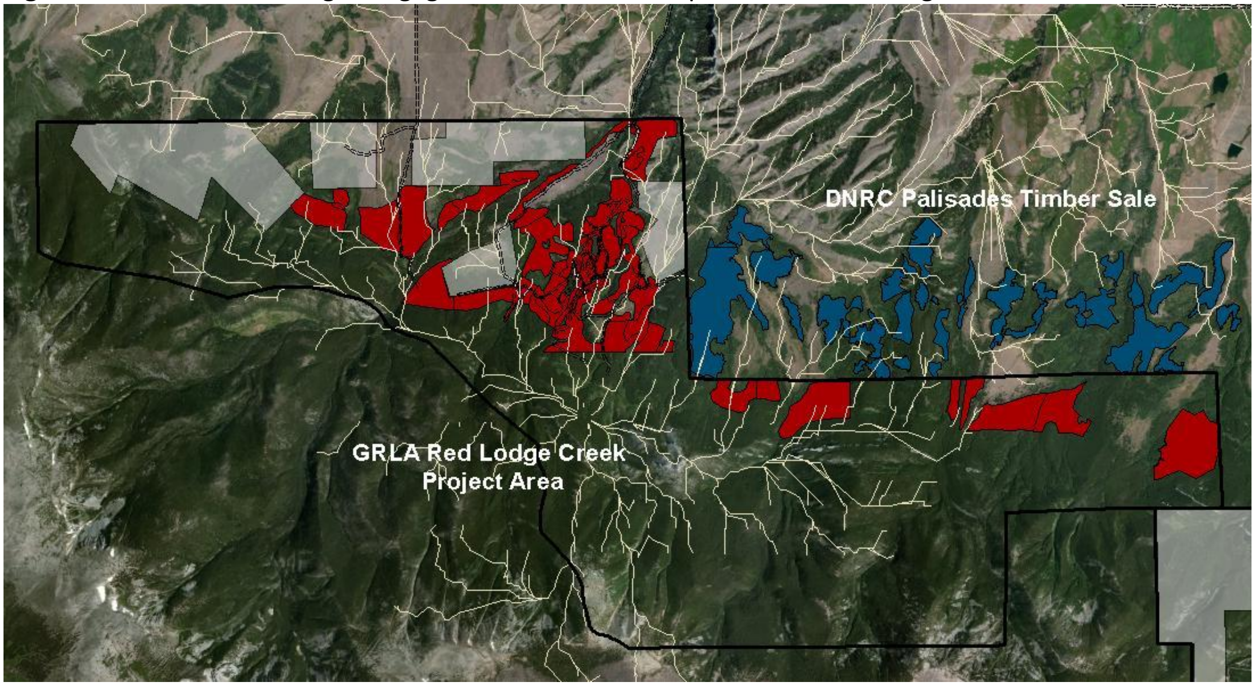


Figure D.4: Alternative 2 human ignition wildfire travel path in the West Fork Rock Creek area.

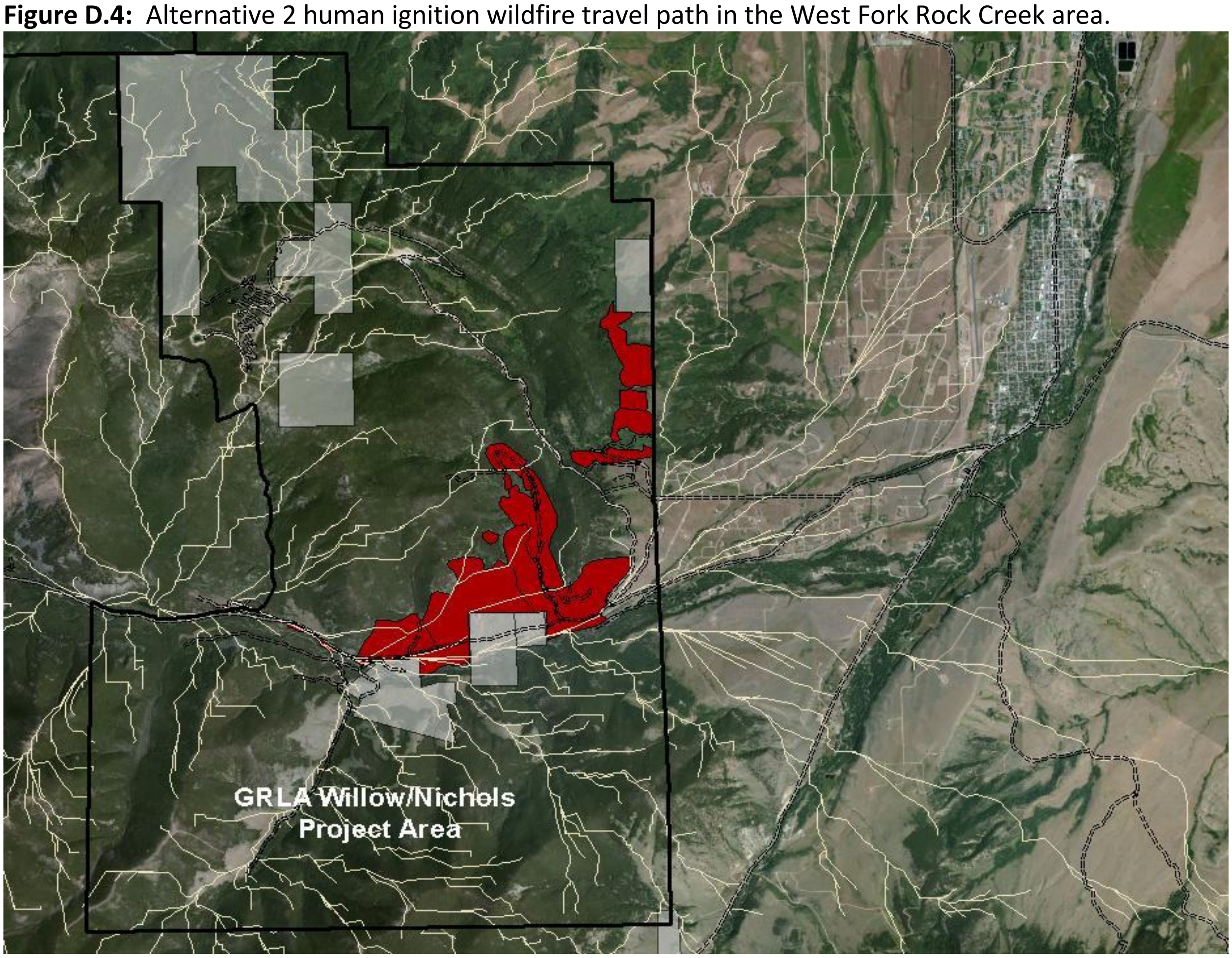


Figure D.5: Alternative 3 lightning ignition wildfire travel path in the Red Lodge Creek area.

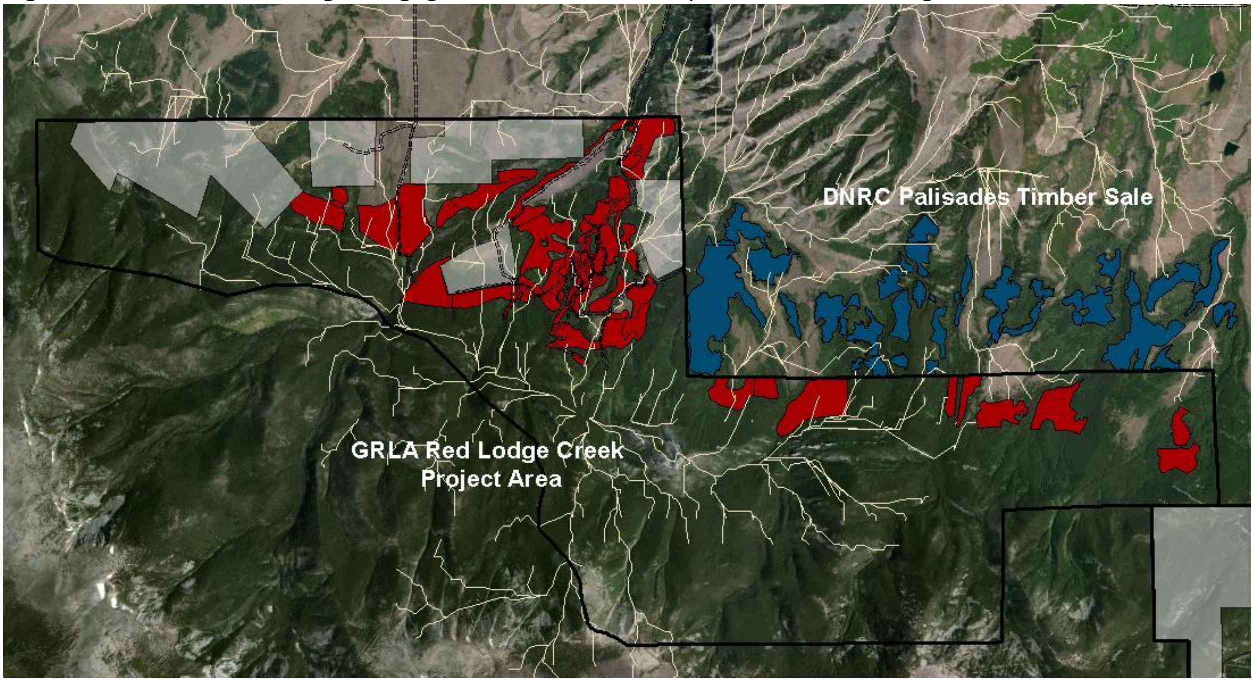


Figure D.6: Alternative 3 human ignition wildfire travel path in the West Fork Rock Creek area.

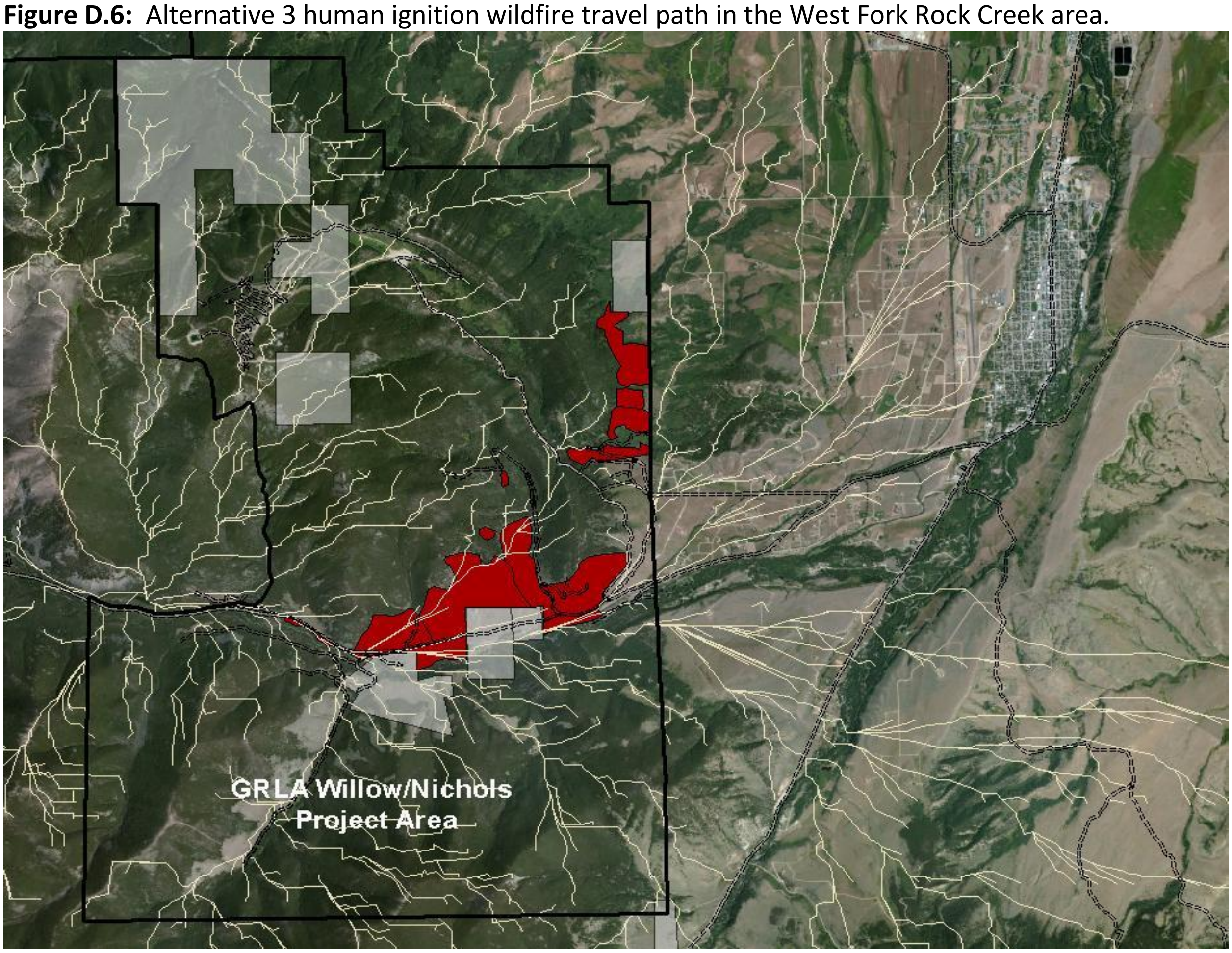


Figure D.7: Alternative 4 lightning ignition wildfire travel path in the Red Lodge Creek area.

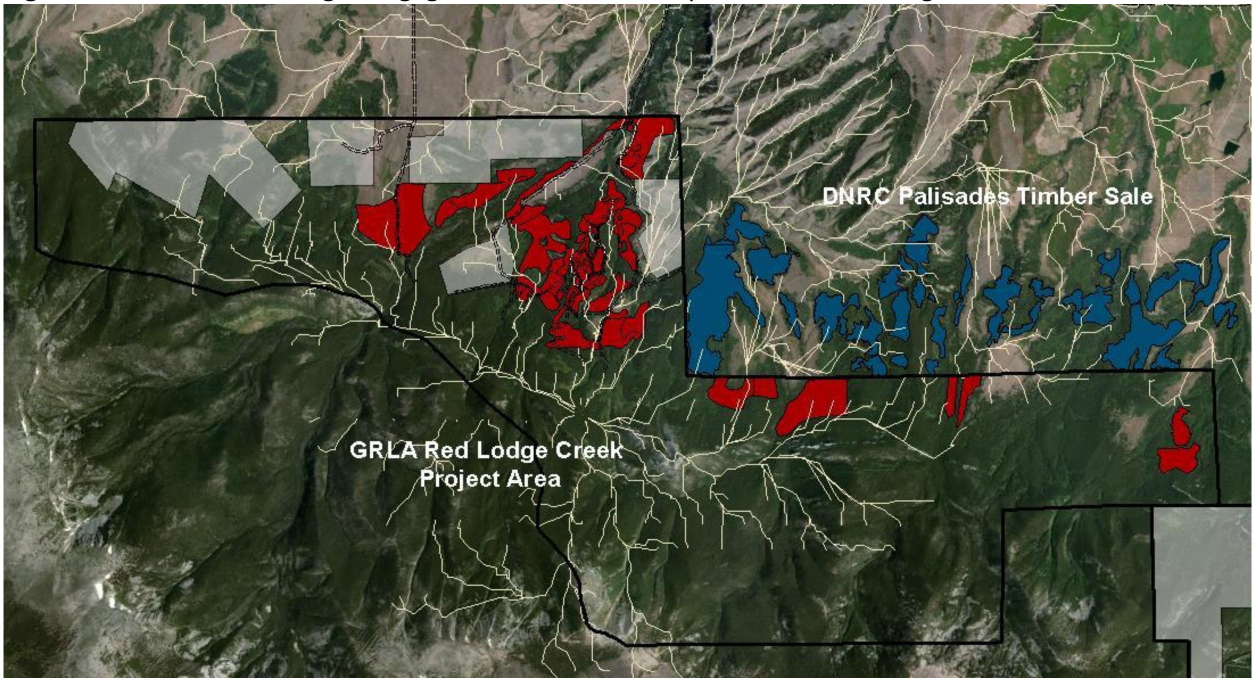
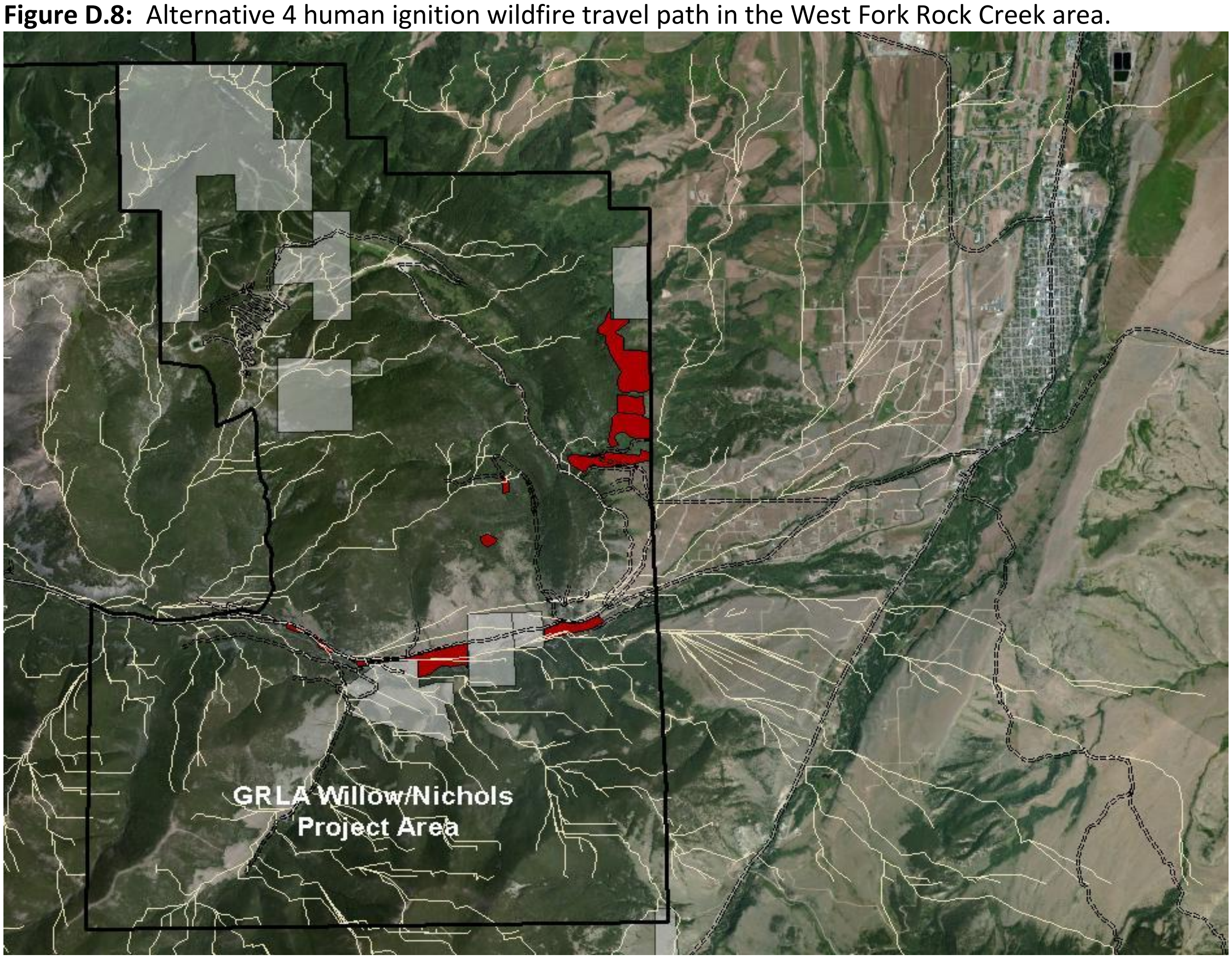


Figure D.8: Alternative 4 human ignition wildfire travel path in the West Fork Rock Creek area.



Appendix B-3, GRLA Fire and Fuels Objection Letter Instruction Responses

Issue 32

Instruction: *For clarification purposes I am requesting the deciding officer to provide a table that shows the breakdown of fire behavior between conditional crown fire and active crown fire behavior. Although the FS provides the full citation in the project record, the case-study example in the FEIS could provide further evidence of the relevancy to the project area by comparing the treatment prescriptions.*

Response: As explained on page 3.14 in the Assumptions section of the GRLA FEIS, both conditional crown fire and active crown fire were combined:

> *Four fire type outputs are produced by FVS-FFE including surface fire, torching (passive crown fire), conditional crown fire, and active crown fire. A conditional crown fire can burn as a crown fire in a stand if it enters as a crown fire from an adjacent stand. These stands often have suitable canopy bulk density to carry crown fire but the canopy base height is high enough that a surface fire cannot easily transition to a crown fire in that stand. This fire type is contrasted with active crown fire which is defined as a crown fire in which the entire fuel complex becomes involved but the crowning phase remains dependent on heat released from surface fuels for continued spread. Active crown fires require surface fuels that burn above a critical intensity and flame length, moderate to high canopy bulk density with continuous crown fuels, and average to below average foliar moisture (Van Wagner 1977). For the purpose of analysis and clear communication in this report both conditional crown fire and active crown fire outputs were combined and were collectively called crown fire.*

Tables B.3.1 and B.3.2 display all four of the original modeled fire types including conditional crown fire and active crown fire.

Table B.3.1: Fire behavior comparison between alternatives for proposed treatment units including conditional crown fire and active crown fire.

	Alternative 1 No Action		Alternative 2		Alternative 3		Alternative 4	
Fire Type	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Surface Fire	961	52%	1,829	99%	1,771	96%	1611	87%
Torching Fire	155	8%	-	-	-	-	42	2%
Conditional Crown Fire	609	33%	2	<1%	75	4%	142	8%
Active Crown Fire	123	7%	17	1%	2	<1%	53	3%
Flame Length (ft)								
0-4	223	12%	1,168	63%	1,007	54%	883	48%
4-8	414	22%	502	27%	624	34%	319	17%
8-11	460	25%	136	8%	140	8%	451	11%
>11	751	41%	42	2%	77	4%	195	24%
Total	**1,848**	**100%**	**1,848**	**100%**	**1,848**	**100%**	**1,848**	**100%**

Note: Action alternatives were compared against the Alternative 1 No Action acres. Acres not treated by action alternatives where figured into fire behavior outputs for each action alternative.

Table B.3.2: Cumulative fire behavior for all alternatives including conditional crown fire and active crown fire.

Fire Type	Alternative 1 No Action		Alternative 2		Alternative 3		Alternative 4	
	Acres	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Non-Burnable	130	<1%	130	<1%	130	<1%	130	<1%
Surface Fire	6,434	29%	7,312	33%	7,126	32%	6,859	31%
Torching Fire	3,037	14%	2,769	13%	2,800	13%	2,824	13%
Conditional Crown Fire	4,897	22%	2,929	13%	2,991	14%	3,059	14%
Active Crown Fire	7,604	35%	8,962	41%	9,105	41%	9,301	42%
Flame Length (ft)								
Non-Burnable	130	<1%	130	<1%	130	<1%	130	<1%
0-4	3,882	18%	5,608	25%	5,423	24%	5,332	24%
4-8	2,220	10%	1,538	7%	1,556	7%	1,305	6%
8-11	547	2%	193	1%	196	1%	274	1%
>11	15,323	69%	14,633	66%	14,846	67%	15,132	68%
Total*	**22,102**	**100%**	**22,102**	**100%**	**22,151**	**100%**	**22,173**	**100%**

*Acreage totals vary <1% between alternatives due to rounding and limitations of working with pixelated data.

Both the Forest Vegetation Simulator-Fire and Fuels Extension (FVS-FFE) and FlamMap 5.0 were used to model crown fire during the GRLA fire and fuels analysis (section 3.1 in the FEIS). The FVS-FFE model produces output data for all four fire types including surface fire, torching (or passive crown fire), conditional crown fire, and active crown fire. The FVS-FFE models conditional crown fire as an active crown fire in terms of flame lengths, mortality, and other fire effects (Rebain 2012). This application of modeled active crown fire outputs for the outputs provided for conditional crown fire essentially demonstrates a tendency to combine the fire behavior and fire effects of conditional crown fire and active crown fire together.